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T R E A T I S E

O N T H E

D I G E S T I O N O F F O O D .

By G. FORDYCE, M.D. F.R.S.

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS, AND
READER ON THE PRACTICE OF PHYSIC, IN LONDON.

*Cum sexaginta numeret Cassellius annos,
Ingeniosus homo est: quando disertus erit?*

MART. VII. 8.

THE SECOND EDITION, CORRECTED.

L O N D O N :

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CHURCH-YARD.

M,DCC,XCI.

T R E A T I S E

ON THE

DIGESTION OF FOOD

BY G. FORDYCE M.D.F.R.S.

LECTURER ON THE FOOD AND DIGESTION OF THE HUMAN BODY
FELLOW OF THE ROYAL SOCIETY OF MEDICAL AND NATURAL SCIENCES



THE SECOND EDITION CORRECTED.

LONDON

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1859.

TO
SIR GEORGE BAKER, BART.
PRESIDENT
OF THE
ROYAL COLLEGE OF PHYSICIANS

THIS
TREATISE
IS
DEDICATED
BY
HIS MUCH OBLIGED
FRIEND AND SERVANT,
G. FORDYCE.

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[17]

ADVERTISEMENT.

THIS Treatise having been read as the Gufstonian Lecture at the Theatre of the Royal College of Physicians, the Author has subjoined the Addreffes which it is ufual to make to the audience before the beginning, and after the end of the Lecture,

The following Work is only the phyfiological part of what the author means to lay before the public. Having fhown in this, that almoft the whole difference in food arifes from its being more or lefs adapted

to the state of the organs of digestion, and that only during digestion, he intends in a second part to show what species of food are adapted more, or less, to the present state of the stomach, and perhaps the other organs of digestion, whatever that may be.

PROËMIUM.

[[iv]]

P R O Ë M I U M.

ROGATU tuo, Præses ornatissime, cujus voluntati obsequi semper pro lege habebo, quorundam e visceribus fabricam et functiones explicare aggredior; dicturus de organis coctionis, quoque modo fiat ciborum in sanguinem conversio. Quæ quum res sit difficilis et obscura, cui, ut par est, tractandæ, omnino me imparem ingenue fateor; oratum te velim, oratos que itidem vos, auditores plurimum colendi, ut benigni veniam mihi detis, sicubi hallucinans levioris aliquid momenti pro argumento adferem, vel doctrinam aliquam, recta ratione non satis fultam et firmatam, tueri coner. Liceat quoque orare, si quid in medium protulero a communi sententia alienum, ut ne me existimetis vel novitatis studio abreptum, vel amore hypotheseôs instinctum;

A 4

instinctum ; quippe qui sola impulsus sim
 cupidine materiam hancce ita rimandi, ut
 auribus vestris non prorsus, quæ dicenda
 habeo, indigna viderentur. Et quanquam
 de rebus medicis prælegendi haud infuetus
 sum, attamen, quum auditores mei nihil
 fere nisi tirones sunt, ignoscetis, si reve-
 rentia virorum artis medicinalis peritissi-
 morum impedimento mihi sit, quo minus
 apte quam deceat eloquar.

Utar nunc, cum bona vestra venia, solito
 eorum more, qui me in hac provincia ante-
 cesserunt, Anglice vos adpellandi ; quo
 more utor libentius, veritus, ex diverso
 meo linguam Latinam pronunciandi modo,
 ne hætenus parum intellectus sim. Idem
 forsitan in nostro ipsorum sermone orietur
 incommodum ex dialecto provinciali ; cui
 rei quum mederi penes me non est, vestra,
 uti spero, bonitas condonabit.

EPILOGUS.

E P I L O G U S.

HOC qualicumque modo, dignissime Præses, Vosque hujus doctissimi collegii fratres, et Vos auditores omnes, assignatum mihi munus exsequutus sum; in quo fungendo exposui pro virili, quibus nititur fundamentis ciborum coctio, quatenus scilicet eam stabilire et figere valuerunt magna eorum conata qui ante nostra tempora florere, ut et majora adhuc molimina hominum hodiernorum—ne quid dicam de mei ipsius tenuioribus conatibus, tam studio quam observatione et experimentis, ut ad sanitatem humanam res quam maxime conferens penitus, si id fieri posset, intelligeretur. Si neque ignota vobis neque nova dixerim, ea tamen quæ ob oculos posui in memoriam revocare poterunt, quæ ipsi olim

olim investigaveritis, quorumque felices effectus adeo mentibus vestris inolevere, ut manu quasi vel filo ducant in diæteticis medicinæ partibus. Si denique vos in hisce talibus erudire ausus essem, id sane futile fuisset, et jure merito summæ arrogantiae vestris omnium sententiis arguerer; quocirca excusatum me volo, quod tantum pretiosi vestri temporis contriverim, præ desiderio aliquid proferendi, quod tritum licet et vulgare sit, haud tamen inutile videatur.

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ON THE

DIGESTION OF FOOD.

LIVING beings, both of the vegetable and animal creation, constantly expend some part of their fluids or solids, or both, when they are exerting any action, or performing any function of life. They may perhaps remain in a dormant state for some time without loss. It is necessary when a loss is sustained, that it should be supplied by the addition of some new matter; and this new matter is called their food. If this matter has not the same qualities with the matter of the parts of the body
which

which are lost, then it is evident that it must undergo a change, and be converted into a substance, possessing the same qualities, and consequently being of the same species with that which was lost.

Without considering the constant loss which I have stated, animals, during a certain period of their lives, are acquiring new parts, and increasing in bulk; and vegetables are continually forming new parts. It is necessary, therefore, that food should be employed to supply matter for this formation and encrease.

There are organs in animals for receiving the food, and retaining it for a certain length of time before it passes into the general system of vessels, which we call the organs of digestion.

In vegetables, although the food differs from the solids or fluids that it is to be formed into, yet it appears to be absorbed by the ends of the fibres of the roots principally,

cipally, and propelled, by some organ subsisting there, immediately into the general system of vessels without any previous alteration. Or it may be taken up often by any other part, as well as the root, and serve equally the purposes of nourishment.

One great distinction between animals and vegetables therefore is, that animals have organs of digestion, in which the food remains for some time before it gets into the general system; and in vegetables the food passes directly into the general system, without being detained, or suffering any previous alteration.

It is to be presumed that there is some object to be attained by the food being stopped for some time in the organs of digestion of animals. The most obvious one is, that the food undergoes some change there.

In different animals the organs of digestion are various, and therefore it is most probable

probable that the changes which take place in different animals are different. Or that the mode of life, or some other accident, renders a different apparatus necessary for this process.

There are other substances beside the food which are poured into the cavities of the organs of digestion from the vessels of the animal himself, which serve either for assisting the change, or enter into the substances formed.

Our present subject, therefore, divides itself: First, into the structure of the organs of digestion in the human body. The substances which are applied to the food during the time of the digestion in the human body. The structure of the organs of digestion, and the substances applied to the food in other animals. The qualities of the substances to be formed by the digestion. The substances that are capable of being digested; their qualities; and if such qualities are different from those of the sub-

sub.

substances to be formed, we are, lastly, to consider the manner by which the peculiar qualities of the food are to be taken away, and the qualities of the substances to be formed given to it.

One principal organ of digestion in the human body is the stomach, which I am now to describe.

It is the business of anatomy to show minutely the exterior figure, the internal structure, the situation with regard to the other parts of the body, the blood vessels, the absorbents, the nerves, &c. which supply the part to be described. But it is not necessary for understanding the functions, or the diseases incident to it, that all these things should be minutely attended to. It is not for example of any consequence to know from what trunks arteries, which go into the stomach, are derived; since they come, like the blood vessels in the other parts of the body, from the nearest larger arteries, are distributed, anastomose, and ter-

B

minate

minate in veins, as they do in the body generally. And the same thing may be said with regard to the nerves, &c.

The stomach is a kind of sack or bag with two openings into it. One of these openings is the termination of a tube which we call the œsophagus, which rises up through the thorax, behind the lungs to the throat, where it is wider, and called pharynx, and communicates with the mouth, so that substances put into the mouth may be forced through the pharynx and œsophagus into the stomach, even when they do not tend to be carried into it by their own weight. The muscles which force the food into the pharynx, and from the pharynx through the œsophagus into the stomach, it is not at present my object to enquire into.

The stomach is rather conical than cylindrical or spherical. It is wider and larger and bulges more out at that end where the œsophagus terminates, which termination is
com-

commonly called the upper orifice of the stomach or cardia; from this part it approaches more to a conical form, and terminates in the other orifice, which we call the pylorus. It is raised up at this end, the pylorus being nearly, but not quite level with the cardia, so as that its upper and lower surfaces form as it were two concentric circles, one on the upper side, which is called the small curvature, and one on the lower or outward and opposite part of the stomach, which is called the great curvature. They are by no means either of them of an exact circular form however, or parallel; but the small curvature is more of a circular form, the large curvature bulging more out to the left from the cardia, which is like a hole opening into a large cavity; this cavity contracts by degrees till it terminates in the pylorus. Sections of the stomach made transversely to the curvatures, are something approaching to circles or ovals.

The stomach is situated immediately below the diaphragm, the cardia where the

œsophagus terminates, being nearly opposite to the middle of the vertebra. From thence it bulges out to the left side, the great curvature coming forward and downward, but more forward the fuller the stomach is. It passes on to the right side, rising upwards, so that the pylorus is not much farther from the diaphragm than the cardia; therefore when a man is in an erect posture, substances must ascend to pass through the pylorus. In a living animal, if there be nothing in the stomach there is no cavity; nor do the sides fall flat upon one another, as they would do by their own weight, or by the pressure of the surrounding substances; but it contracts so as to retain its proper form, and so as that the inner surfaces are every where brought into contact; and when any substance gets into it, it distends and enlarges the whole of it in equal proportion; especially if the substance be solid or fluid. There is some doubt if this be the case when vapours are contained in it, for upon opening living animals, there is such violence done to the motion

motion of the intestines, as we shall afterwards have occasion to notice, that we cannot quite trust to the appearances of irregularity of contraction that present themselves. As far as we can judge by our feeling, vapours distend the stomach unequally in some cases.

It is to be observed, that vapour in the stomach, or indeed in any part of the intestinal canal, is always a morbid affection.

The stomach consists externally of a membrane, which is derived from the peritonæum, which meets nearly at the interior curvature, being joined together by cellular membrane, and is reflected so as to cover the whole stomach. This membrane, however, coming from both sides, goes off at the large curvature, forming the exterior membranes of the omentum, which connects it with the surrounding parts. The interior surface is connected by means of cellular membrane, to a layer of muscular fibres,

fibres, which run in a longitudinal direction, that is, from the pylorus towards the upper orifice, irregularly, and with whitish spaces between them, as if they were tendinous fibres, which are irregular. This layer is connected with another layer of muscular fibres which lies within it; but the fibres of this layer run transversely, one fibre not appearing to go quite round the stomach, but rather like segments of circles connected with one another, with something like tendinous parts. Those fibres of this layer, which are in the great curvature, have their pole, if I may so speak, at the end of the curvature, where it bulges out, and not in the cardia. The interior layer or coat is stronger apparently than the outer. Between the external and internal layers, there are two other layers, of about nearly an inch in breadth, which cross one another obliquely at the upper orifice, and are dispersed upon the sides of the stomach; and on each side at the small extremity there is a tendinous or ligamentous band of about a third part of an inch, which terminates

terminates in the pylorus. These are situated between the external coat, and the outer layer of muscular fibres*. On the inside of the interior muscular layer there is cellular membrane, which is looser near the muscular fibres, and grows gradually firmer and thicker, till it forms the base of the interior surface. Anatomists have commonly considered this as two coats, calling it the nervous and villous coat. But as far as I can judge, it seems to be nothing but cellular membrane growing thicker and thicker, until on the inside of the stomach it becomes sufficiently firm and close to retain the substances contained in the cavity of the stomach; so that I should conceive that there is, properly speaking, no smooth or fibrous interior coat of the stomach at all. Observations made with microscopes are extremely subject to fallacy from deception of vision. On viewing the surface of the stomach with magnifiers of different kinds, and with different lights, and when the sto-

* It is clear that by means of these, motion may be produced in all directions.

mach is of different degrees of moisture or dryness, the appearances are extremely different. The manner in which I have been able to get it most distinct, was by placing a small portion of the interior part upon a small circular plate of ivory, with the surface outward and in view; this small plate of ivory was fixed in the centre of a circular plate of glass, which fitted the stage of a compound microscope, and a silver concave mirror was applied at the object end of the microscope to reflect the light, as usual in viewing opaque bodies. When the surface was moderately moist, there appeared a number of fine thin membranes, crossing one another so as to form a number of irregular cells; and the surfaces of each of these membranes were covered again by finer and smaller membranes again crossing one another, so as to form lesser and shallower cells, so as very much to increase the interior surface; and this appearance accords with what is seen by the naked eye, or a glass of little magnifying power, and very much resembles a piece of pumice stone broken.

broken*. In these cells a number of small white unequal globes were seen lying, but detached; nor could there be seen distinctly any glandular appearance.

The stomach, as we have already said, is never flat or flabby; but it always retains its form in the living body, and is applied to its contents. It is capable of much greater distension and contraction than any other cavity in the body. It is always full however, whether it contains an ounce or a quart, or any other quantity of any solid or fluid matter, as I have already observed.

The two orifices of the stomach differ from one another in this. The œsophagus, and its opening into the stomach, are both of the same size, so that considering the œsophagus, there is no contraction at the

* The laminæ which form these cells are extremely vascular. Some anatomists have supposed them covered with a fine epidermis; certainly they are not penetrable, except by vessels in the living body.

cardia;

cardia; but this is not the case with the pylorus, it being contracted more than the duodenum, as well as narrower than the end of the stomach. So that if both cavities, to wit, the stomach and duodenum, are full, the pylorus would appear like a hole between them. Round this contracted part there is a particular set of circular muscular fibres, which are distinct from both the muscular fibres of the stomach and duodenum.

In the stomach glands are found, dispersed in the cellular membrane under the innermost coat or layer of muscular fibres. These glands open by excretory ducts into the cavity of the stomach; the ducts have been demonstrated in the human body by Mr. Cruickshank, and other anatomists.

The glands are situated principally towards the pylorus.

The stomach is endowed with absorbents similar to the lymphatics, as they arise from other cavities.

The

The pylorus forms a communication between the stomach and small intestines. These have been divided into the duodenum, jejunum, and ilium. Some have disputed this division, and consider the whole as one tube without any distinction. But the duodenum differs very materially from the jejunum; the difference between which and the ilium it is not my present business to enquire into. It is true that the precise point cannot be fixed at which the duodenum terminates, and the jejunum begins on the inside; yet this does not make it proper to consider them both as one intestine. For in like manner, animals and plants run into one another, so that it cannot be determined in some cases whether a living being be a plant or an animal; yet nevertheless it is clear that plants and animals are totally different from one another. On the outside the jejunum is said to begin where the mesentery takes its rise.

The duodenum begins at the pylorus, and turns immediately backwards and downwards

wards for a short way, then turns towards the right kidney, to which it is a little more or less attached, and from thence it passes before the artery, the vein of the kidney, and vena cava, ascending gently from the right to the left, just before the aorta and the last vertebra of the back : it continues this direction from thence obliquely forward by a slight curvature, which has been considered by some anatomists as its termination.

The exterior coat of the duodenum is derived from the peritonæum ; it does not however cover the whole of the intestine, but the peritonæum coming from each side, does not meet or approach so near as it does either in the exterior coat of the stomach, or the lower intestines. The back of the duodenum may therefore be considered as without a peritonæal coat, and only covered with cellular membrane. This structure of the duodenum, like the going off of the peritonæal coat of the stomach at the great curvature, gives an opportunity of
greater

greater distension than can take place in the lower intestines. Under this peritonæal coat there is cellular membrane which connects it with the muscular coats or layers of muscular fibres.

The external muscular layer is longitudinal, or running in the direction of the intestine; not so strong in proportion to the interior coat or layer, as that of the stomach to all appearance; but stronger in proportion, than the exterior muscular coat or layer of the lower intestines, is to the interior. It is not so firmly connected by the cellular membrane to the interior layer as in the smaller intestines, but more firmly connected than the two muscular coats or layers of the stomach. These exterior longitudinal fibres cannot be traced, so that one fibre can be demonstrated to run the whole length of the duodenum. Nor do they terminate in any evident tendon.

The interior coat, or layer of muscular fibres, is transverse, going round the intestine, the fibres not always forming a complete circle

circle like a ring, nor exactly perpendicular to the line of collimation of the intestine; but they are sometimes segments of circles, or ovals, or curves, approaching to these, rising and being lost insensibly. Under these, or within them, there is cellular membrane.

The interior surface of this intestine has very different appearances when viewed in a microscope according to the application of that instrument, in many views being subject to optical deception. Some part of it has been described by authors as a prodigious quantity of small tubercles; this appearance, however, arises from its being dry, or viewed with a side light. Near the pylorus, when viewed in the manner I have already described, it looks very similar to the stomach, only with small ridges which seem to run longitudinally. With an opaque microscope, nothing like pores or glands can be seen in it. Lower down, the surface appears somewhat more polished, and transverse ridges become more considerable, till the appearance of what are called *valvulae conniventes*, gradually becomes more complete.

Into

Into this cavity two large excretory ducts enter about the bottom of the first curvature; one, the ductus communis choledochus, bringing bile from the gall-bladder and liver; the other, the excretory duct of the pancreas; these open together into the duodenum. The duodenum appears, as well as the stomach, to be capable of greater dilatation than the jejunum or ilium; for, as we have already observed, in the sound state of the body it is always contracted so as to be adapted to its contents; or, if there be nothing in it, so that its surfaces shall be brought into contact.

The jejunum and ilium differ from one another in some points, but not so much as from the duodenum, and in circumstances which are not material to our present enquiry. They are situated in, and occupy the principal part of the abdomen; where they are coiled up, or rather hung by a membrane which we call the mesentery. It is formed by the peritonæum coming from both sides of the abdomen, which meet at the vertebræ, and are continued on, (being connected by cellular membrane, forming

forming a flattish membrane) until they come to the intestine; they then divide, and passing round the intestine, unite at the back as one membrane without any division; as if a piece of cloth was folded, and a finger being put into the fold, the cloth was applied close to the finger and brought together at one side, and glued afterwards so as to make a double flat piece of cloth. This membrane is so formed, as to occasion the intestines to make many volutions in such manner, as that substances passing along them must sometimes descend, and sometimes ascend. Under this there is a longitudinal coat, or layer of muscular fibres, which are extremely fine. There is an internal layer, composed of fibres that go round the intestines in the same manner as in the duodenum, only that they are more attached to the exterior coat. Within this coat is cellular membrane, which thickens gradually until the interior membrane is formed. This internal membrane differs greatly from that of the stomach, and first part of the duodenum, being a smooth polished membrane, which doubles

doubles in the diagonal direction of the intestine, and forms folds which hang loose from one another round the intestine on the interior surface, not exactly in rings; these have been called *valvulæ conniventes*. That these are duplicatures of the interior membrane is evident, because if we blow air into the cellular membrane, between the internal membrane and the muscular coats, they disappear. On examining their surface with a microscope, they appear again to be covered with other smaller duplicatures of the same kind. The surfaces of all these appear polished, excepting, that on the edges of the smaller ridges there is somewhat of the same cellular appearance that there is in the stomach*. The jejunum and ilium are nearly cylindric, and capable of being blown up with air to a considerable size, but do not seem to distend, especially the jejunum, with any solid or fluid substance to any considerable bulk.

* The interior surface is certainly covered with an epidermis which gives this polish.

There are glands in the duodenum, lying in the cellular membrane, within the interior muscular layer, which have orifices entering into the cavity of the duodenum, and similar glands in the jejunum. These seem to be most numerous in the duodenum near the pylorus.

Fluids pass into the cavity of the stomach, duodenum, and jejunum, in great quantities, not only from the large glands, i. e. the liver and pancreas, but also from the smaller glands which are found, as we have already mentioned, and are numerous, in all the intestinal canal; and likewise most probably from exhalants: for we find not uncommonly large quantities of watery fluids thrown off from the stomach in vomiting, even although a former fit of vomiting not five minutes before had emptied it. Upon examination, although there was often bile and slimy matter thrown up in such cases; yet I have seen several instances of its being water, with a small quantity of the salts of the blood, and which

which therefore would appear to have passed immediately from the blood vessels through the exhalants, without being affected by any gland. The qualities of these fluids we shall consider afterwards.

We come now to treat of the varieties found in the structure of the organs of digestion in other animals.

In the first place, in some other quadrupeds, and likewise in birds and other animals, there are reservoirs for containing the food for some time previous to its entering the stomach where the digestion appears to go on, which stomach Mr. Hunter calls with propriety the digesting stomach. In some animals these cavities retain the food in such manner as to be brought back again into the mouth to be farther bruised and comminuted by the teeth. In others it would appear that it was reserved in the first cavity to be thrown gradually into a cavity, which in birds and some species of fish is surrounded with a strong muscle, or

rather muscles, and lined with a cartilaginous or horny membrane. The birds pick up stones, which by the motion in this cavity grind the food, and perform the office which teeth do in other animals. Spalanzani, and others, have denied that they were of this use, and have affirmed that the stones were picked up by mere accident, the animals mistaking them for seeds. But I have examined this particularly in experiments I made in hatching eggs with artificial heat; I have hatched vast numbers, and frequently have given the chickens small seeds whole, taking care that they should have no stones. In this case the feed was hardly digested, and many of the chickens died. With the same treatment in every respect, others who had their feeds ground, or have been allowed to pick up stones, have none of them been lost. With tolerable care, when common chickens are once hatched by artificial heat, they are easily brought up without a hen, as by instinct they will keep in that part of the furnace
where

where there is the proper degree of heat, and the proper exposure to air. Instinct also teaches them what substances they should choose for food, and what quantity of stones is necessary to intermix with it. For if a very large quantity of small stones be mixed with a small proportion of grain, they will pick out the grain, so that the proportion of stones which they swallow shall be very little, if at all greater than when only a few were intermixed. In those I examined the proportions of stones were not at all greater when there was a large quantity of them mixed with the grain, than when there was a small proportion; and I have often observed them choosing one piece of stone, and rejecting another. Birds have also an evident instinct even to distinguish one kind of earth from another, as may easily be seen in Canary birds; the hen, at the time of her laying her eggs, requires a quantity of calcareous earth, otherwise she is frequently killed by the eggs not passing forward properly, as I have in many instances observed, to one set of

hens a piece of old mortar was given, which they broke down and swallowed, certainly not mistaking it for Canary feed, or any kind of food, but distinguishing it from a piece of brick, which they did not either break down or swallow; another set at the same time were kept without any calcareous earth; many of these died, while the others, although otherwise exactly in the same circumstances, were none of them lost. It appears therefore that birds have a necessity for stones being swallowed for digestion, and earths for other purposes, and that they have an instinct which disposes them to choose the proper quantity and quality required. Moreover, as Mr. Hunter observes, the noise of the grinding may be heard, and therefore there can be no doubt that this stomach is made to contain stones for the same purposes for which teeth are employed.

In all those animals which have this kind of stomach, there is a cavity, although not often a very large one, into which the food

food passes from the gizzard, and which may be considered as the digesting stomach, analogous to the stomach in the human body.

The craw in birds therefore seems commonly to be a mere repository to feed the cavity of the gizzard, like the hopper to a mill; and the gizzard may be considered as the millstones grinding the matter that is afterwards to be digested in the digestive stomach.

Another purpose cavities in which the food remains for some time are employed for, may be to soak the food thoroughly in watery fluids, that so it may more easily be afterwards made to undergo the processes of digestion.

These previous cavities seem therefore to be for three purposes: First, for a reservoir to retain food, which is to be afterwards ground down by the teeth; secondly, to serve as a reservoir to supply the gizzards;

and thirdly, to make a previous maceration of food to give it a disposition to enter into the digestive process.

Animals, who live on animal food alone, have no cavity for the purpose of bringing the food again into the mouth to be chewed, nor any reservoir for previous maceration. Such of them as have gizzards, the contents of which are always very small, require a reservoir to contain food for supplying the cavity of the gizzard.

In the stomachs of some animals, the glands are much larger and more conspicuous. Perhaps they may secrete a fluid different from the gastric juice in the human body. But this we do not know by experiment.

The liver, and therefore the secretion of the bile, is hardly ever wanting in animals which have regular stomachs and intestines.

The

The pancreas, although very various, is wanting only in insects.

In all animals the digesting stomach is terminated by a pylorus, which divides it from the duodenum.

The duodenum is also distinct and different from the jejunum, although the exact point cannot be determined where the one ends and the other begins; and the differences are similar to what we have already described in the human body.

In animals, who live on animal food, the intestines are shorter than in those who live on vegetable food. Those who live partly on animal, partly on vegetable food, have an intermediate length of intestine.

The jejunum in animals living on animal food has no *valvulæ conniventes*. But the surfaces of the intestines in all animals are greatly enlarged, having risings in them of a variety of different kinds, which give them

them an immense surface in proportion to what they would have, if their interior surface were perfectly smooth and polished. The risings which we find, must often increase the one surface, more than the other would be, many hundred times.

These are the remarks which I have to make on the difference between the stomach and intestines of men, and other animals which have regular stomachs and intestines from whence fluids are carried into another set of vessels, such as are called blood-vessels in the human body.

But there are animals which have no circulation of fluids as far as we can tell. For they have only one cavity, which serves them both for heart and stomach. This cavity has generally many membranes rising up in it, which break it into a kind of different chambers, communicating with one another by large vacant spaces. The food is received into this cavity, and is undulated backwards and forwards from one end of it
to.

to the other. This we can see in many of them by means of a microscope, as I have myself often observed.

In these animals there is no reason to suppose that there is any gastric juice, such as is found in the stomachs we have already described, or bile, nor pancreatic juice.

I suppose that there are vessels rise from this cavity, and branch out to the several parts of the body of the animal, in the same manner that the juices pass in vegetables.

These animals, therefore, are something between animals and vegetables. The food is digested in the stomach, and so far they partake of an animal nature. It is absorbed, and carried to nourish the various parts of the body, and in so far it resembles vegetables, which have no heart, and of course no circulation.

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It has been a dispute among natural historians, whether certain species of these were actually animals or vegetables. For example, in those corals which are called keratophytos, the animal where it receives the nourishment, is clearly a polypus, living in a calcareous habitation which it forms like shell-fish. But it is attached to what has the semblance of a tree, or rather the stem and branches of some of the algi, only when distilled by itself, it yields volatile alkali, and the empyreumatic oil of animals; but so do the fungi, although they have been considered as vegetables. It is a question, whether this common stem and branches in keratophytos is to be considered as dead or alive. The only reason for believing it to be alive, is its not putrefying; but then it is to be considered that both this, and the stems of the algi that are similar to it, are hardly capable of being brought to putrefy long after all life is certainly gone out of them.

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The short sketch which I have given of the form of the digestive organs in animals not of the human species, is only of such parts as are necessary for the purpose of the following argument. Whoever wishes to be more particularly informed on this subject, must wait for my friend Mr. Hunter's publishing those observations, which long and unwearied labour, joined with what so rarely happens, that it will exceed the belief of posterity, a clear and accurate determination of the points which are to be illustrated by experiment and observation, and a power of inventing and prosecuting such experiments and such observations as tend to no frivolous purpose, but to the true evidence and illustration of the propositions brought forward, of which there are none that are not important.

I come now to consider the substances applied to the food during the digestion.

It is unfortunate when it occurs in treating on any subject, that there is a necessity of

of employing new terms, or adopting words already used, but in a different signification, because it is some time before the ear adapts itself to a new sound, and gives the meaning of a word to the mind without reflection, which interrupts the apprehension of the argument. It is equally difficult to take a word that has a vague sense, and confine it to a precise meaning. However, it is necessary for me at present to meet this difficulty, and to use terms which must be employed precisely to one meaning, or in one sense.

A term we shall have occasion to make use of is *mucilage*, which has been employed but in a very loose and vague manner, and in a sense generally different from that in which I mean to take it; so that I had thoughts of inventing altogether a new name. But the mind is so apt to rest itself upon technical terms, and conceive that when they are learnt, science is possessed, which opinion is the greatest of all fallacies. This has happened unfortunately

more particularly in schools, and has been lately carried to a great length in some schools of medicine.

The errors arising from new names are greatly increased, if they be of Greek origin ; since that gives them still a greater power of creating veneration, and an appearance of inspiration of knowledge. For this reason I choose to make use of the term mucilage, which I thus define.

Mucilage is the name of a class of substances ; not a generic or specific name.

This class of substances is found only in animals and vegetables.

The substances forming this class, if put into a water-bath, and kept exposed to heat in open or distilling vessels, all become solid in consequence of water evaporating from them.

If

If it be in distilling vessels, what we find distilled over is water.

If the heat employed has been moderate, so as not to alter the properties of the substances, and if the distillation has been such as that fermentations have been prevented from taking place, upon returning the water distilled over, or an equal quantity of pure water, the matter returns again to the same state that it was in before the distillation, and has exactly the same properties.

The solid matter which remains after the distillation is inflammable.

If the heat be encreased after it becomes solid, and the receiver be changed, there comes over a fresh quantity of water, commonly amounting to more than one half of the weight of the solid substance.

Empyreumatic oil and volatile alkali, or an acid, likewise come over in vegetables,
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commonly an acid and empyreumatic oil of a peculiar smell. In animal substances volatile alkali and empyreumatic oil having a different and more pungent smell.

But there are exceptions ; for I dried several species of that class of plants which are called by Tournefort, cruciform ; and by Linnè, tetradynamia, both by evaporation and distillation. The drying was performed in a bath, whose heat was greater than that of boiling water ; it was formed of a solution of neutral salts in water ; in this heat fermentations cannot take place. I put the solid matter left into glass vessels, and distilled it with a red heat. The empyreumatic oil was similar to that produced by distilling animal substances, such as bones, and there was volatile alkali dissolved in the water, and no acid produced*.

I do not know any case where distilled vegetable acid has been found on distilling

* Vegetable alkali was found in the residuum.

animal mucilage by itself, or an empyreumatic oil, similar to that produced from most vegetable mucilages.

Mucilage is capable of being combined with water, and is found always naturally combined with water forming fluids, or solids, of a greater or less degree of viscosity and flexibility, the degree by no means depending upon the quantity of water they combine with, as is shown from this experiment.

Farinaceous matter, starch for instance, may be dissolved in water in a moderate degree of heat, so as to form a fluid of no very great viscosity; but boiling it, gives it immediately a great degree of viscosity, without evaporating the water.

An idea has obtained, that when mucilage unites with water, so as to form a solid, that it has only imbibed the water into its pores, and has not combined with it chemically; but this is totally erroneous; for

for water imbibed into the pores of any substance, which is in itself brittle and inflexible, cannot give it pliability or flexibility. As for example, a piece of pumice-stone having imbibed water into its pores, becomes indeed somewhat less brittle; the non-elastic power of the water preventing its vibrations, but it does not become in the least more flexible or pliable. Farther, if you imbibe the water from any animal or vegetable solid by means of a cloth, or flour, or any mechanical means whatever, it will maintain its flexibility and pliability as perfectly as before. As also animal mucilages combined with the same quantity of water, are some more, some less, flexible, and pliable. For example, if we take a membrane or cartilage, and dry them thoroughly by wiping, and put them into a distilling vessel, which is placed in a water bath, whose heat is encreased by dissolving neutral salts in the water, the same quantity of water distills off from each; but the cartilage is much less flexible than the membrane before the water is thus separated.

There are three modes of combination of mucilage with water. First, it may be combined with water, so as to form a solid. Secondly, it may be combined with water, so as to form a fluid, not diffusible through water, of which we find an example in the mucus; or it may form a fluid perfectly diffusible through water, as the serum of the blood, or solution of gum arabick are.

In all cases I use the term mucilage for the substance which is left solid after the water has evaporated or distilled off in a heat which does not alter its properties, and in a manner which does not allow it to be altered by fermentation.

The next property which distinguishes these mucilages is, that they become entirely soluble in water, so as to form fluids by long boiling; or by being confined with water in a close vessel, so as to be heated to a greater degree than that of boiling water, which is commonly called Papin's Digestion.

Mucilage,

Mucilage, therefore, taken as the name of a class, includes animal and vegetable substances, solid, brittle, inflammable, decomposable by heat, capable of being combined with water in their natural state, capable of being combined with water by decoction, or Papin's digestion, so as to form a fluid.

To this definition I mean to adhere strictly, and especially to remark that I never mean to annex the term to a solution of this solid substance in water.

This class of substances, to wit, mucilages, are subject to a particular chemical operation, which takes place in no other kind of matter whatever, and which we call coagulation.

The term coagulation has likewise been used in a very vague sense. We must therefore endeavour also to make a strict definition of this term, which I shall always adhere to.

By coagulation, generally and vaguely, has been meant the conversion of the whole of a fluid into a solid. Thus when a saturated solution of ammonia præparata in water, formerly called spirit of sal ammoniac, is mixed with pure alcohol, the two fluids apparently become solid, and form a mass which we call offa helmontiana. So when alcohol is applied to the white of an egg, a similar appearance of solidity takes place.

There is, however, a very great difference between these two operations. In both cases the alcohol occasions the water to separate from a solid matter: in the offa helmontiana, the alcohol attracts the water more strongly than the ammonia præparata does, it unites with the water, and precipitates the ammonia præparata in so fine a powder, and in such quantity as to take the whole of the compound of alcohol and water which is fluid to moisten it. But if this compound of alcohol and water be separated, the ammonia præparata is as soluble in water as it would be if it was procured,

cured by any other process. This then is a mere precipitation. In like manner, if we take a saturated solution of ferrum vitriolatum in water, and mix it with a saturated solution of mild fixed vegetable alkali; that is aqua kali præparati, formerly called lixivium tartari; the kali will unite with the vitriolic acid, and separate the iron in the form of a calx; the kali vitriolatum will be partly dissolved in the water which was in the solutions before they were mixed, and partly will remain in a solid form in fine powder, which, together with the calx of the iron, will take all the fluid, to wit the solution of the kali vitriolatum, to moisten it. The whole, therefore, will become solid to appearance. This has also been often called coagulation. But here the calx of the iron is separated from the acid, and united with gas, without any particular alteration in its qualities; and the alkali, which is considered as the coagulating substance, is combined with the acid, and has no effect on the calx of the iron.

On the contrary, when we apply alkohol, alum, or any other substance which coagulates the white of an egg, the alkohol, &c. unites likewise with the water, precipitates the mucilage from it, and so changes the mucilage, that it will not dissolve in water again, as it would have done, if it had not been acted upon by the alkohol, &c. For if we take the white of an egg, and expose it to a heat not greater than 140° of Fahrenheit's thermometer, we may evaporate the water, and leave the mucilage perfectly and readily soluble in water again. The alkohol, &c. therefore, besides precipitating the mucilage of the white of the egg, produces an alteration in its qualities, to wit, in its solubility in water.

This mode of alteration of quality is totally different from all other means of altering qualities which we find in chemistry. For in all other cases, qualities are only altered by combining a particle of matter, with a particle of another species of matter, or separating two particles of two different species

species that were before combined. But in the present instance no part of the alkohol, &c. unites with the particles of the mucilage, neither the alkohol considered as a simple substance, nor any of its elements; for I have distilled off the alkohol with a gentle heat not nearly sufficient to coagulate the mucilage, and I recovered the whole of it, so that it might be applied to a fresh quantity of white of egg which it will coagulate equally, and so that by repeating this operation, one ounce of alkohol might have been employed to coagulate the whites of all the eggs that ever have been, or will be, produced. In like manner, without employing any greater degree of heat than that of the atmosphere in this country; I washed out the whole of the alum, so as to procure exactly the same quantity that would be procured if the alum had been originally dissolved in pure water, and not applied to the white of the egg, and the water had been again evaporated.

Animal

Animal and vegetable solids, as well as fluids are, as we have already observed, compounds of mucilage and water. Coagulation may therefore, and does, take place in animal and vegetable solids as well as fluids. But in solids it has been called by other names, as astringency, corrugation, tanning, &c. yet there is no difference whatever between the operation in fluids and solids, excepting that when the water is separated from the mucilage with which it unites so as to form a fluid it becomes solid, but when the water is separated from a mucilage with which it forms a solid naturally, it remains solid, but of a firmer texture,

The only difference that coagulation produces in the properties of mucilages, either animal or vegetable, is in their solubility in water, by occasioning them to separate partly, or entirely, from the water with which they were combined. In every thing else they remain the same in themselves; they are equally solid, equally affected with heat; they

they have the same colour, taste and smell ; they have the same specific gravity ; they are affected in the same manner by acids, alkalis, and all other substances that they were before their coagulation ; that is to say, that if we coagulate a portion of any of them, and dry another portion by a heat not capable of coagulating it, so that in both cases the whole water is separated without decomposing the mucilage itself, they are perfectly undistinguishable, excepting that that which was dried without coagulation, will combine with water again in the same manner that it was combined before, and that which was coagulated will not,

It is to be observed, that all colourless animal mucilages are exactly the same in all their properties after coagulation. This appears from many experiments that I have made, but the detail of which would be tedious and not instructive. Suffice it, that if the serum of the blood be cleared of all extraneous matter, the coagulable lymph be also cleared of all extraneous matter ; the

white of an egg, the mucus, the skin, a tendon, a muscle, a membrane, a cartilage, be each cleared of all extraneous matter and coagulated, it is impossible to distinguish by any chemical experiment or investigation which was which, or what the coagulum was produced from ; therefore all colourless animal mucilages differ from one another only in their solubilities in water ; that is, one is soluble in one proportion, another is soluble in another proportion ; one combines with water forming a fluid diffusible through water, another forming a fluid not diffusible through water, another forming a solid not diffusible through water, of more or less softness, flexibility, distensibility, or elasticity.

After an animal mucilage is coagulated, it may be re-dissolved in water by boiling it for a considerable time, or by macerating it in water in Papin's digester. And such solution differs only in one respect, whatever the coagulated mucilage may have been, to wit, that the solution is sometimes a little

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more viscid with the same proportion of mucilage contained. But even this difference is hardly sensible, if the heat employed has been very considerable, or the boiling continued for a very long time.

I come now to consider the properties of the substances applied to the food, during its digestion in the human body, which are formed in the body itself, for the purposes of digestion.

These substances are the saliva, which is formed by glands, whose excretory ducts open into the mouth. The gastric juices, which are either formed by glands in the stomach, or thrown out by the exhalents. The bile, which being secreted in the liver, and rendered more perfect in its peculiar properties in the gall-bladder, is afterwards carried into the duodenum. The pancreatic juice, which is secreted in the pancreas, and carried into the duodenum along with the bile. The fluids secreted by the glands of the

the intestines, and those thrown into the intestines by the exhalents.

It would lead into long details of little or no use to our present subject, if we were to describe the structure of the several glands and vessels which furnish these fluids. We shall, therefore, proceed to consider the properties of the substances themselves.

The investigation of the properties of the several animal fluids by proper chemical experiments, I may say was hardly begun before my time, when I myself investigated the properties of many of them, as appears by my thesis, in which the properties of mucus, and Dr. Ramsay's, in which the properties of bile, and some others of the same kind, are investigated. I also instructed Mr. Hewson, who was a pupil of mine, in the manner of investigating their properties. The particular experiments which I have made to ascertain the properties of those which I am now about to consider, would take up too much time to
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give the detail of, I shall therefore confine myself to short recitals and narrations of the results.

The saliva is a fluid, consisting of water, with which a colourless mucilage, and saline substances, are combined. The saliva, the compound of these substances, is viscid. It is not absolutely indiffusible in water, for if we rub it along with pure water in a mortar for some time, it may be made to diffuse through it very equally, so as not to be retained by a filter, but to pass through along with the water, or prevent the water from passing through. The mucilage is coagulable, but not readily : in as far as I can judge, it is coagulable by some of the gastric juices, but I have not been able to satisfy myself thoroughly in this point. The salts contained cannot easily be determined, because of the difficulty of obtaining a quantity sufficient to examine them. For although we can encrease the secretion by means of medicines, yet we have all the reason that can be to believe that when they
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are so encreased in quantity, the quality is always very much varied ; that in some cases it is we are certain, because the fœtor, which attends the encreased secretion in many instances, is a property which does not at all belong to the saliva in its natural state : we are obliged, therefore, to trust to such experiments as we can make on small quantities. That it contains sea-salt there can be no doubt, because if we let it evaporate properly in a glass vessel, and examine the residuum, cubic crystals of sea-salt are plainly to be seen, but mixed with other cristallizations, some of which resemble those of common sal-ammoniac, whose crystals are remarkable, as being double pyramids each of four sides, joined at the base like those of the ruby, only that the height of the pyramid is much greater in proportion to the breadth of the base ; these pyramids adhere to one another always at points, and so that the diagonals are in straight lines, or form right angles with one another. Moreover, volatile alkali may be separated from the saliva by means of fixed vegetable alkali,
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and muriatic acid, by means of solution of silver in nitrous acid; muriatic acid, it is true, might be separated from the sea-salt. There are also to be found other cristallizations of various and irregular forms, which, if one was to judge a priori, might be the same with the salts found in the serum of the blood.

The saliva has been considered by Mr. Macbride as a ferment. The ground of this opinion arises from his having made experiments, in which pieces of meat and water were mixed together alone, and where pieces of meat, water, and saliva were mixed together in similar phials; upon letting them stand, air-bubbles were found in the phial, in which the meat, water, and saliva were contained, before there were any found in the phial in which the pieces of meat and water were alone contained. The result was the same when bread and water, and bread, water and saliva were compared; and also when bread, meat and water; and bread, meat, water and saliva were compared.

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pared. But no deduction can be made from these experiments, by which the power of the saliva to induce fermentation can be grounded, because the saliva giving viscosity to the water would prevent vapours from rising in small and imperceptible bubbles ; and would retain them until they became more numerous, and until they united together so as to become more sensible.

Many physiologists have considered the saliva as secreted in very large quantities during the deglutition of the food ; but I can hardly be of that opinion. As far as I can judge, the secretion during a meal can hardly exceed an ounce or two, and I should think that it serves only to lubricate the passages through which the food is to pass. It is true that the great apparatus of the parotid and sub-maxillary glands, which is employed, as well as perhaps some smaller glands which open into the mouth, gives an idea that something very material is to be obtained from the effects of this fluid. But when we consider again that the moment

ment the saliva gets into the stomach, it is probably coagulated by some of the gastric juices, and then becomes exactly the same as any other coagulated animal mucilage, and that the salts are principally sea-salt and sal-ammoniac, and the quantity of water is immaterial; it is extremely problematic, whether it has any effect in the changes which take place in the stomach. It is true that sea-salt would seem to serve some purpose in the digestion of the food; for wherever mankind have been enabled to procure it, they have always employed it along with the food; and not only men, but other animals. It is well known that cattle in this country thrive in salt marshes. In North America salt is necessarily employed in fattening the cattle; and many animals are guided by instinct to eat salt when it comes in their way. But then the salt contained in the saliva is in very small proportion, and there is at least as large a quantity in some of the gastric juices, which are probably much more copious, so that that which is contained in the saliva can be

but of very little effect. I should, therefore, presume, that the saliva has little or no effect in the digestion of the food in the stomach.

The next substance which is applied to the food is the gastric juice.

Many physiologists seem to conceive the juices secreted in the stomach as perfectly homogeneous. But we shall find this to be by no means the case.

When an animal has been recently killed, the stomach being empty, there appears generally a small quantity of a glary fluid, which has a coagulating power. But in vomiting, it happens often, that after one fit of vomiting, a second takes place in eight or ten minutes, the patient bringing up a large quantity of watery fluid nearly colourless, and sometimes without viscosity, and that when nothing has been given to drink. I have in many cases examined this fluid, and found it to be water, with a small

small quantity of the neutral salts of the blood, with little or no mucilage in it, and without any coagulating power, differing therefore from the coagulating gastric juice. It is probably not thrown out by any gland, but by the exhalents of the stomach. And it is extremely probable that similar fluids are thrown out during digestion, as before observed.

The coagulating power of the gastric juice was undoubtedly well enough known for a very great period of time, since the infusion of the stomach of a calf has been employed in all ages to coagulate milk to form cheese. But it must also be remarked, that medical authors conceived that the cause of milk being coagulated in the stomach of infants, was owing entirely to acid produced in the stomach; and that, therefore, an infant's bringing up curdled milk, was a sure sign of acidity in the stomach.

Dr. Young, of Edinburgh, on examining this opinion, found that an infusion of the inner coat of the stomach, which had been previously washed with water, and then with dilute solution of mild fixed vegetable alkali, so that there could not be a possibility of any acid remaining in it, coagulated milk very readily. He found also that it had a power of coagulating serum and other coagulable mucilages.

The coagulating power of this substance is very great. Six or seven grains of the inner coat of the stomach infused in water, gave a liquor which coagulated more than a hundred ounces of milk.

We cannot be sure whether this matter be a solid or fluid: in either case it seems to be not very readily diffusible through water; for in order to get out the whole coagulating power from the stomach, it requires that it should be infused in water for a considerable length of time. Take the inside of the digesting stomach of a calf, and infuse

fuse it in water for six hours, and rinse it with clean water, and put it into a fresh quantity of water, it will still give an infusion which has strong coagulating powers. Moreover, from Dr. Young's experiment of washing the inner coat of the stomach in a dilute solution of alkali; and afterwards infusing it in water, and finding it still give a considerable degree of coagulating power to the water, it would appear to be very difficultly soluble; otherwise the solution of the alkali would have carried it off, it having great power, even if the solution be very dilute, of clearing the surfaces of animal solids from any substance adhering. Further, a quantity of watery fluid being vomited up without bringing the coagulating substance along with it, shows that even water flowing from the exhalents, and which we should therefore expect would throw off the whole of any substance from the surface of the stomach, does not bring it off.

Perhaps the cells which we have already described as forming the interior surface of

the stomach, and which are at last very minute, may hide and retain the coagulating matter, so that watery menstrua may not readily get at the whole of it.

The stomach has, besides the coagulating matter and the watery fluids which we have described, a mucus which covers it in the same manner as mucus covers the surfaces of other mucus membranes. But it is very difficult to separate these actually from one another, so as to get a mass of each distinct, and so as to be able to examine them chemically. Possibly those small globular bodies which were discovered lying in the cells of the stomach, as before related, may be the coagulating gastric juice. But this is mere conjecture, and might be accidental in the stomachs I examined; especially as they were both injected, and one of them had been preserved in spirits, the globules may have been some part of the injection coming out without the colouring part.

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Although it be difficult actually to separate the several juices formed in, or thrown out into the stomach, yet we have a clear and distinct idea of each of them.

The mucus having properties similar to the mucus in the other parts, and which at present it is not our object to take notice of. I have described them above thirty years ago, in the inaugural dissertation which it is usual to publish on taking a degree at Edinburgh.

The juice which flows from the exhalents is mere water, in which the neutral salts of the blood are contained in larger or smaller proportions. And the coagulating juice is a solid or fluid difficultly diffusible through water, having a strong power of coagulating many animal, and perhaps some vegetable mucilages.

In disease, the stomach has a power of forming other substances, perhaps many. We see for example a blackish matter sometimes

times thrown off in vomiting, which certainly is not bile, it being not at all bitter to the taste, or having the smell of bile. It certainly has not its colour from red particles of the blood thrown out, having nothing at all to the naked eye, or to the microscope, of any appearance of the red particles. Sometimes substances are thrown up similar to those which form themselves upon the tongue in fever, and various other diseases; but of these substances there is not the least mark in a healthy stomach, and it is not necessary, therefore, that we should consider them.

The coagulating gastric juice, as far as we can judge, is a colourless substance, and without taste or smell; and, in as far as its coagulating power is useful or necessary, it does not appear that it is requisite to be, or that it is, in any great quantity.

In the duodenum the bile is applied to the food after it has probably gone

gone through some process in the stomach.

The bile varies somewhat, it being mixed sometimes with a little serum, and sometimes no such intermixture takes place.

The apparatus for secreting the bile is immense. In all the glands of the body there seems to be a difference between the vessels destined for the secretion, and those destined for the circulation. But here the difference is very great indeed; the vessels destined for the secretion being the veins of the abdominal viscera gathered together, and uniting in one trunk, which enters the liver, the gland for the secretion of the bile, and divides in the manner of an artery, excepting that it does not appear that its branches anastomose. This peculiar structure has made many physiologists conceive, that the bile was prepared in the abdominal viscera, or the blood made ready to form it by a degree of putrefaction in the intestines, or some other operation. But on opening
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a living animal, and taking blood from the vena portarum, the trunk which enters into the liver, repeating the experiment in several animals, there was no appearance of bile more than in any other of the veins. It is true that authors have been deceived as well as other anatomists, by examining the blood in the vena portarum, when an animal has been dead for some days, in which case the interior polished surface of the gall-bladder is destroyed, and the bile suffered to exude and contaminate every thing near it. But that is not the case in a living animal, or in an animal recently dead. The difference between venous and arterial blood, as far as we can gather from experiment, is only that the red particles are of a pure red in the veins, and scarlet in the arteries. And as we find the exhalents are constantly throwing out a quantity of water, together with a small portion of serum, the venous blood must contain less water in proportion to the red particles and coagulable lymph than the arterial, although some physiologists have thought the coagulable lymph

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is likewise thrown out by the exhalents, misled by a fallacy which it is not to our present purpose to expose. Nor can we draw any conclusion relative to the formation of the bile from this very singular mode of its secretion.

Many physicians have been led to suppose, that bile was constantly contained in the blood-vessels, misled by that very superficial cause of delusion, viz. the serum being of a yellowish brown colour, which they have supposed was derived from the bile. But let them take water, and mix bile with it so as to give it the colour of serum, they will find that the taste of bile will be extremely strong, so as to leave no doubt, when compared with the yellowest serum, that its colour does not in the smallest degree depend upon the bile. Whenever bile gets into the blood-vessels, it is secreted by the finest secretory organs of the body, and gives the thinnest secreted fluids the property of dying yellow, which always marks with certainty the presence of bile, no other fluid

giving this quality. Another cause of error is, that there are other fluids of a yellow colour and bitter taste, but otherwise of properties totally different from the bile, such as the wax in the ear, which is both yellow, bitter, and diffusible through water; but upon the application of an acid is not decomposed, nor is there any resinous substance separated.

This part of the argument may seem digressive from the subject we are treating of, but it relates to it very strongly in this, that bile, as we have already observed, is thrown into the duodenum of all animals who have intestines as well as a stomach, and which bile is totally consumed, altered, or destroyed, in the intestines, no part of it being absorbed by the lacteals and carried into the blood-vessels.

To return to the secretion of the bile. The secretory vessels placed in every part of the liver throw the bile into ducts, very improperly called pores; it is true, indeed, that

that every hole must have length as well as diameter; but who would call a tube of many inches in length a pore? These ducts, or tubes, unite, until they are at last all united into one tube, which is called the hepatic duct. From the side of this rises another tube that leads into a bag which is called the gall-bladder. The bile runs through this duct into the gall-bladder, where it remains for some time, and grows yellower and more bitter than it was in the tubes, commonly called *pori biliarii*, or in the hepatic duct; it is afterwards thrown back again where it entered from the hepatic duct, and passes down through a continuation of the hepatic duct into the duodenum; this continuation of the duct has been called the *ductus communis choledochus*, through which it is obvious that either the bile arising from the liver immediately, or that part of it which has stagnated for some time in the gall-bladder, may pass into the duodenum.

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The bile is a compound of mucilage and water. The mucilage is not in itself coagulable, but sometimes there is a mixture of coagulable matter, probably serum, along with it. It is capable of being diffused through any quantity of water, but in the gall-bladder it is united with such a quantity as to render it a fluid of oleaginous viscosity. When it is combined with that quantity of water with which it is found united in the gall-bladder, it is not more putrescent than the serum of the blood. But if it be diffused through a large quantity of water, it putrefies much more readily.

Give me leave here to remark, that I take these conclusions from experiments which I have either contrived and made myself, or which I have gotten others to make under my inspection ; or which being contrived and made by others, I have either been present at their being performed, or have repeated them. But it would run this lecture into too great length and detail, and
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draw off the attention too much from the main subject, to give the particular history of them.

Bile is of a yellow colour, verging somewhat to a green; of a bitter taste, with something like sweetness. It has a peculiar smell, and differs but little when combined with water, as it is in the gall-bladder, in its specific gravity from water. It is somewhat heavier.

These sensible qualities are not of any consequence to our present subject; we mention them only to mark, that this mucilage is very different from the colourless mucilages of the body. What is of more consequence is, that the mucilage is decomposed, not coagulated, by acids and some of their compounds, the acids precipitating a part, which is resinous in so far as that it melts in a moderate degree of heat in the same manner that vegetable resins do. It is also soluble in alkohol, but incompletely. It has the peculiar smell of the species

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of

of animals in which it is produced, and is a pretty powerful anti-putrescent. What the other part is which the acid acts upon, has not hitherto been investigated.

The mucilage of the bile seems to be always decomposed in the duodenum, and the resinous matter evacuated, since otherwise we should have every reason to believe that it would be absorbed by the lacteals and carried into the blood-vessels, where, as I have already observed, bile is never found, excepting in a morbid state of the body, that is, when a man is affected with jaundice.

The pancreatic juice is another fluid. It is secreted by the pancreas, a gland not unfimilar to some of the salivary glands. This gland has no reservoir, so that it is difficult to come at any quantity of the juice secreted by it, and thrown into the duodenum. Upon inserting a small quill into its duct in a living dog, there flowed out a colourless fluid almost watery, having a
faltish

saltish taste; and on letting it evaporate upon a plate of glass, crystals were seen evidently of common salt and sal-ammoniac, as far as we could judge by their figure, which was confirmed by applying a little of this juice to solution of silver, and making other such chemical experiments as we can make on very small quantities of matter, which however found rather a ground of conjecture than satisfactory proof. Besides these salts, and probably the other salts commonly contained in the blood, there is found upon evaporation a colourless muci-
lage, which re-dissolves in water, but whose compound with water is not very diffusible through water, although somewhat more readily than the saliva. These are all the properties that I could determine in the small quantity that was thus collected. It is farther to be observed, that the secretion did not take place in the natural state. For the quill inserted into the duct might stimulate it, and occasion a different secretion, at least in some points, from that which naturally takes place; and it is impossible to

get a quantity of this juice collected in the duodenum, because were we to tie up the ductus choledochus so as to prevent bile from contaminating it, still there are many other glands in the duodenum which secrete fluids; and there are also, most probably, exhalents that would likewise throw out a quantity of fluids which would also be mixed with it, even if we tied up the pylorus and the duodenum below the entrance of the ductus choledochus, and the secretory duct of the pancreas.

The other glands which are found in the duodenum we have great reason to believe are for the purpose of secreting some peculiar fluid for some particular use. But I never could contrive any means, nor do I know any have been contrived by others, by which any such fluids have been, or can be collected, so as to be made the subject of experiment. Therefore our belief of their secreting a particular juice rests entirely upon our not finding parts made in animals and vegetables generally without use,

use, and finding that those whose purposes we could not at first very well ascertain, on further investigation, were employed for very necessary functions.

There is mucus formed on the surface of the duodenum very evidently.

These are the substances that seem particularly applied to the food, and are necessary or useful for the formation of the chyle, part of which at least is completely formed in the duodenum. It is not therefore necessary that we should pursue our enquiries into the fluids that may be added in the jejunum and ilium.

SUBSTANCES CAPABLE OF BEING EMPLOYED FOR NOURISHMENT.

We now proceed to consider the next part of our subject, to wit, what substances are capable of being employed for the subsistence and nourishment of animals in ge-

neral, and more particularly in the human body.

Vegetables afford nourishment undoubtedly for animals ; but vegetables themselves are nourished. If we have but one seed of a vegetable, a seed of mustard for instance, and clay, sand, and pure distilled water, and the air of the atmosphere, we can produce an infinite quantity of vegetable matter. None of the clay or sand does any thing to the production of this vegetable matter, they only afford a support to the roots and stems of the plants which grow in them. The water then, and the air, and other vapours which form the atmosphere, supply the whole nourishment of plants, or vegetable matter produced.

Water is an homogeneous substance. It has been conceived lately to be a chemical compound ; whether it be or no, and if it be, what are its elements, are certainly not established by the experiments which have been lately made in respect to it.

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The vapours which form the atmosphere are very various. We know only two of them, air and gas. These make together little more than a fourth part of the vapours which constitute the atmosphere. It is a question, therefore, whether air, gas, or the other vapours, or water, is the pabulum, or what gives sustenance and nourishment to vegetables.

Light has an effect on vegetation ; but it may go on in perfect darkness ; and, therefore, although light is useful, yet it forms no part of the nourishment of vegetables.

Vast numbers of experiments have been made to determine the effects of different vapours on vegetation. But in my opinion, there is not any one of them which has contributed in the smallest degree to elucidate the effects of vapours of different kinds ; for they have been all made on vegetables confined in a small space, when every one who has seen plants grow in an hot-house shut up from the air, will imme-

diately be convinced that appearances which take place in a plant, shut up in a receiver containing a gallon or two at most, are not to be depended upon.

There are many vegetables which grow under water. To see whether these vegetables required any thing but pure water and pure air for their nourishment, I sowed seeds of several of them in pure distilled water impregnated with pure air. The seeds grew, and plants were formed completely, so that there was much more vegetable matter in the whole plant than in the seed; and, therefore, it is clear that the other vapours which are found in the atmosphere besides the air, are not at all necessary for the production of vegetable matter, consequently not for the nourishment of vegetables.

It might perhaps have been an object that would have elucidated this subject somewhat more, if the experiment had been tried with the purest distilled water,* without being impregnated with air. My object at that
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time was only to determine whether those vapours which are mixed with air in the atmosphere were necessary for the nourishment of vegetables. But my time has generally been too much engaged to run into the investigation of collateral enquiries.

Water, therefore, and pure air, are sufficient for the nourishment of vegetables.

Vegetable matter sustains vast numbers of animals. Many animals live on animal food alone; but the animals on whom they live are sustained by vegetables. The lion may live on the horse, but the horse derives its nourishment from grass. Therefore those animals which live on the flesh of such other animals as are sustained by vegetables, may be considered as ultimately living on vegetable food.

It has been a very universal idea, that all animals live either on vegetables, or on animals whose nourishment is derived from vegetables; but the practice of keeping gold fish in glasses with common water, without giving

giving them any kind of food, suggested itself to me as extremely singular, and gave some kind of appearance of there being either some animals originally in the water in which they were kept, or that insects laid their eggs in such water so as to afford nourishment to the fish, either from the eggs themselves, or from the maggots, or other imperfect animals produced from them; I therefore put some gold fish into a glass vessel, and supplied them with water taken from a deep spring, and which water contained a very small proportion of *magnesia vitriolata*, and *natron muriatum*, together with a still smaller proportion of *calx vitriolata*. This water was changed at first every four-and-twenty hours, and afterwards every three or four days. The fish lived in this manner for fifteen months, grew to more than double the size, and threw out considerable quantities of *feculent matter*.

As it was possible that these fish might have lived upon something that might be contained in the water from the spring, I
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took distilled water, and impregnated it with air of the atmosphere, it not having been at that time known how to separate pure air from the other vapours with which it was mixed. Indeed nobody at that time conceived that there was so small a proportion of pure air in the atmosphere, it being now known, since the experiments made by Dr. Priestley, that the atmosphere does not contain a fourth part of its whole bulk of pure air. I put other gold fish into the distilled water so impregnated, and kept them for six months, during which time they also grew, and threw out fæculent matter. It might still happen that some insects might have formed in, or have come of their own accord into the water, which might therefore have served for nourishment. To avoid this fallacy, I corked up the vessel in which they were contained, and still found that they lived and grew, and emitted fæculent matter, as in the former experiments. I have since found moreover that pure air, procured either from nitre or minium, blown into distilled water, served

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for their living, growing, and emitting feculent matter.

Therefore it cannot be doubted, that animals may live on pure air and pure water; and that their fluids or solids may be immediately produced from these substances.

Although gold fish may thus live on water and air alone, yet they have organs for digesting animal food; and when in health they, as well as other fish, are very voracious.

If we contemplate generally the inhabitants of the sea and other waters, we should be at a great loss to comprehend how such infinite numbers could be supplied with food, if some of them were not able to subsist on water and air alone. The quantities of polypi, which in forming their habitations, produce those immense masses of coral which rise from the bottom of the deep, sometimes almost perpendicularly
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where it is unfathomable by any line, could never find subsistence from vegetables, none of which grow within a thousand miles of them.

Oysters, and a vast variety of other shell-fish, are fixed to the rocks on which they grow ; or they bury the remains of their progenitors, by growing upon them, without being able to go in search of food, if it does not present itself to them.

The sea is thickened with myriads of small insects and reptiles, with which it often glows as if on fire, at vast distances from any land where any vegetable could be procured.

Even herrings, and other fish which migrate, go in shoals of such length, breadth, and thickness, that those in the middle and towards the end could hardly expect to find the smallest remains of food, as it must all be devoured by the front of the shoal ; yet we find that all of them have their roes
equally

equally filled, all of them are equally fat and well nourished. It is not so with a species of deer, called spring-buck, which travels in immense herds in the southern parts of Africa, eating up every green thing in their passage. Those in the centre and rear become emaciated and enervated, and an easy prey to lions, hyenas, and other carnivorous animals, which their great swiftness, when in health and strength, renders them out of all kind of danger of,

Fish being capable of living upon water, impregnated with air, and being also capable of digesting animal or vegetable food, while they cannot be pressed for want, have all the luxury of epicures. A jack in a pond may devour all its subjects, and live without them sole master of his dominions, while other tyrants are confined to the massacre of a few only, being obliged to retain some, often much against their inclination, for their own existence.

Although

Although vegetables are capable of living on water and air alone, and animals are also capable of being nourished by these substances, yet nevertheless a vegetable is better nourished by absorbing other substances into its roots, and an animal by vegetable and animal substances already formed.

I do not mean to enquire farther at present into the food of vegetables, but only to observe that they are all nourished by water and air, or by substances already formed from water and air.

I proceed, therefore, in the next place, to consider what parts of vegetables can be converted into the juices of animals.

There are various solids and fluids in vegetables, having a vast variety of different properties.

Their fluids may be considered as of two kinds, such as on evaporation leave a mucilage

lage behind, and such as on evaporation leave no mucilage behind.

Excepting in as far as water may be considered as nourishment to animals, the watery parts which evaporate can hardly be conceived to be digested ; for it is probable, that when aquatic animals are nourished by water and air alone, that this water and air does not go through any process in the stomach and intestines, but gets into and is altered in the body much in the same way as in vegetables.

All the solids of vegetables consist of mucilages combined with water, excepting resins and other oils or oily substances.

We may consider, therefore, the whole nourishment which animals derive from vegetables as consisting of their mucilages.

It seems most probable, that none of the resinous parts are digested : vegetable resins,
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them, leave mucilage behind, and such as leave no mucilage behind.

All those which leave mucilage behind, are capable of serving for the nourishment of animals of some one or more species.

All animal solids consist of mucilage and water ; sometimes mild calcareous earth and calx phosphorata are deposited in the bones or other harder parts. But in every solid there is always mucilage and water ; and all animal solids are capable of giving nourishment to animals of certain species ; therefore all animal solids, and fluids containing mucilage, are capable of giving nourishment to some one or other animal, even those which are the most deadly poisons. Cantharides are greedily devoured by two species of insects, not part of them picked out from other parts, but the whole entirely, without leaving a vestige of any the least part of the cantharis. I have procured these insects from chests of cantharides imported from Sicily, and which had lived upon the
cantharis

cantharis for many months. After being washed with water slightly, these insects have juices perfectly bland, so that if they be bruised and applied to any the most sensible surfaces of the human body, they produce no inflammation, nor have any appearance of possessing any matter having a stimulating quality.

In animals as well as in vegetables, there are expressed oils which appear, as we shall afterwards have occasion to observe, perfectly nutritious.

Therefore all animal and vegetable solids, and all animal and vegetable fluids containing mucilage, and expressed oils, and possibly essential oils in the form of resins, are capable of giving nourishment to some one or other species of animal.

I come in the next place to consider what substances are capable of giving nourishment to the human body.

Medicine being, as far as we can trace it in all countries, in its first beginnings in the hands of men, infected with superstition, every part of its doctrine has constantly been affected with that weed, and the dietetic part perhaps more so than any other. We find always in the mouths of those tainted with this original sin, that man is to live naturally and on such food as is presented to him by nature. Little men, and forgetful of the Almighty's decree, that man shall earn his bread by the sweat of his brow, and of course find out all kinds of substances from whence he is to procure subsistence; and if he cannot by his industry find out vegetables, or animals which may serve him for subsistence, he must cultivate and alter them from their natural state. Accordingly men live, in as far as they live on vegetables, on such as are no where to be found growing naturally. Wheat, rice, rye, barley, or even oats, are not found wild; that is to say, growing naturally in any part of the earth, but have been altered by cultivation; that is, by the industry of mankind,

mankind, from plants not now resembling them even in such a degree as that we can trace from whence they drew their origin ; and not only these, but most of the other vegetables that we employ. A plant of scanty leaves, and a small spike of flowers, not weighing altogether half an ounce, is improved into a cabbage, whose leaves alone weigh from fifty to an hundred pounds, without counting those which are expanded, or into a cauliflower of many pounds weight, being only the embryo of a few buds, which in their natural state would not have weighed so many grains ; the plant itself, in its natural state, not only being nothing in its bulk, but in its quality the reverse of nutritious.

I am not, therefore, to enquire what is the natural food of man, who has no natural food ; but into what he has been able to render proper for his nourishment, and been able to produce for himself by his own industry.

I will take this subject in another light. It may be thought that man is in this respect miserable beyond all animals without any recompense: but man is destined to inherit the whole earth; not according to Ovid and some of the other ancient poets, to live only in the temperate zones, but to live and even be numerous in the torrid and both the frigid zones. The torrid zone is indeed the most congenial to man in his natural state. There vegetation and animation go on so quickly, that food is easily procured, and raiment is not wanting: but other difficulties occur perhaps from ravenous animals, violent diseases, and other circumstances which are quite foreign to our present subject, and which I shall not digress into. Suffice it to say, that I am to enquire into what food human industry has found for the human species.

The first that I shall take notice of is a vegetable mucilage, which is called farinaceous matter.

Farina-

Farinaceous matter is found most particularly in the seeds of that great division of plants called gramina : a division which has been particularly considered, and appears to be principally intended for the nourishment of animals.

Some of these gramina have been altered, as I have already hinted at, by cultivation, so as to afford seeds much larger, and therefore giving a much larger quantity of nourishment than they do in their natural state. It would be carrying this research into too long a detail to enter minutely into the description and cultivation of this principal food of mankind. We shall content ourselves with the following observations.

The gramina, as well as the other plants known and used by the Greeks and Romans, are so ill defined, that we cannot tell certainly what they made use of, or whether those remain which they had brought to perfection, or whether they have been lost, and others have been brought anew

from natural plants, which have been varied from their natural state, so as to produce them.

Rice can only be cultivated in warm climates, and in lands either altogether or nearly overflowed with water. This grain contains more nourishment for its bulk than any other pure farinaceous seed whatever. It has however a small quantity of astringent matter mixed with the farinaceous, and between the husk and the seed there is a small proportion of sugar. Rice delighting in moisture, although the crop be heavy, does not exhaust the ground so much as might be expected.

Wheat, for its bulk, contains farinaceous matter next in proportion to rice, and has the farinaceous matter more pure than any other seed, having the least astringent matter mixed with it, and very little if any sugar between it and the husk. As it is the purest and best grain, so it requires the greatest labour in its cultivation.

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The other species of grain may be considered only as substitutes for rice and wheat, and are only cultivated for food, where wheat or rice will not grow, or where wheat exhausts the ground to such a degree, as that it is not capable of bearing successive crops of it. We may except maize, which in moderately warm countries is easy of culture, and produces large quantities of farinaceous matter, mixed however with such astringent matter as gives it somewhat of a disagreeable taste,

The farinaceous matter in the seeds of all the gramina, is the same as it is also in all other plants, and parts of plants which produce it.

In the seeds of the gramina there are three substances, besides farinaceous matter. Sugar generally contained between the husk and the cotyledon, or between the external husk, which was formerly the flower, and the proper seed, consisting of the husk, cotyledon and embryo; this sugar is most probably

probably produced during the flowering, and has not been destroyed ; it is in largest quantity in rice and rye. Secondly, a mucilage, which is very apt to fall into fermentation, and which is in the largest quantity in rye and barley, so as to render them somewhat apter to fall into fermentation. Thirdly, an astringent juice apparently similar to the ordinary astringent matter in other vegetables.

That the farinaceous matter is the same in all these seeds, and only mixed with these other extraneous matters is evident, because these other substances may be destroyed by steeping the seeds either with or without the husks in water for six or eight hours, pouring off the water, and applying fresh, and so persisting for some time, until the other substances are washed off, or destroyed by fermentation. The farinaceous matter remains solid, and in a fine powder. If the husk were present and the whole be bruised down and passed through a sieve, the farinaceous matter subsides in the form
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of a white solid substance, and may be separated from the water by subsiding, filtration and evaporation ; it is found to be the same in all its qualities from which ever of these seeds it is procured, and is called starch.

We must not, however, consider starch as farinaceous matter, absolutely free from any alteration, although there seems to be a very small degree ; for those parts of it which have undergone any fermentation are probably washed off, along with the other extraneous matters mixed with it in the seeds.

Another natural class of plants which have been called legumina, plants having flowers which have been thought by some botanists to resemble a butterfly, and which by Linnè are called, according to his whimsical denomination of classes, diadelphia decandria, seem also destined very much for the food of animals ; but all of them are naturally unfit for the nourishment of mankind.

kind: By culture an astringent matter, which is found in their seeds is destroyed, so that the farinaceous matter which they contain is rendered sufficiently pure for use; nevertheless the same culture produces in them a considerable quantity of that muci-
lage which is so apt to fall into fermenta-
tion.

Perhaps this class of vegetables might not be cultivated so as to produce ripe seeds for food, if it were not for the advantage the farmer finds in taking alternate crops of them and the gramina.

Nuts are seeds of trees generally, but so various in their botanical distinctions, that they cannot be classed otherwise, than that there is an external hard covering, within which, when it is first formed, there is something somewhat resembling cellular membrane in an animal. In the middle of this is the embryo of the seed contained in a peculiar membrane, and in which is included the embryo of the young plant after
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the flower is over. Within this membrane a white, and what has been called a milky juice, is formed and contained. This milky juice consists of sugar mucilage, disposed to fermentation, and probably expressed oil; of this, however, I only judge by external appearances. That there is oil has not been clearly made out by any experiments that I know of; and I have never had time to institute a set of experiments to determine the point. By degrees this milky juice thickens, increases, and expands or dilates the internal membrane in which it is contained, the cellular membrane between it and the husk being gradually compressed, apparently killed, and rendered fibrous, until the membrane, covering what has now become two cotyledons, generally is applied to the external hard coat, which we call the shell.

The cotyledons consist of farinaceous matter, mixed with a large quantity of expressed oil, and sometimes a bitter juice, which has been held in some cases poisonous, but, that it is, admits of very considerable

able doubt. Essential oil is very often found in large quantities, in the husks of these nuts. It is a question whether it is not also in some instances dispersed through the cotyledons, but that is not perfectly determined.

The expressed oil contained in these nuts, has the property of preventing the other matters from being washed off, in such manner as to form starch from them, by any means I have hitherto been able to employ ; but their coagulability by heat, and other properties, show clearly that they contain a large proportion of farinaceous matter.

There are many other seeds of vegetables of various classes that abound with farinaceous matter, and which might be employed for nourishment, if human industry had exerted itself to cultivate them, as it has those which I have now enumerated. The seeds of the cucurbitaceæ, for instance, contain farinaceous matter in as pure a form as the gramina, and even might

vie with the best of the gramina, as starch can be equally made from them; but the quantity is like a drop in the ocean. The seeds of other vegetables vie with nuts in the mixture of farinaceous matter, and expressed oil, such as, for example, the seeds of the poppy, which possess no part of the narcotic juice of the husk in which they are contained.

I am inclined to think that fruits of vegetables also contain farinaceous matter, even apples, peaches, apricots, and more particularly perhaps the bread fruit. But this opinion is but a conjecture, no experiment having been made to ascertain it.

The stems of some vegetables, particularly of that natural class which is called palmæ, I also suspect to contain farinaceous matter, a powder, according to the accounts which we receive from the countries in which they grow, being beaten out of them, made use of for nourishment, and formed into a substance we call sago; which, although

though it cannot be well determined without opportunities which are not easily procured in this country, I have great reason to conjecture to be the product of farinaceous matter.

The roots of plants of many classes contain large quantities of farinaceous matter ; of these the potatoe contains it in the purest form, and is emulous of the seeds of the gramina. Besides the farinaceous matter, it contains evidently a considerable quantity both of sugar and that mucilage which is disposed to fermentation ; but it is void of the astringent matter which exists perhaps in the seeds of all the gramina, although not so discernable in wheat, rye, and barley. The other matters may be easily washed off, so as to leave a farinaceous matter in the form of starch.

There are some roots, such as *bunium bulbocastanum*, which are natives of this country, that have farinaceous matter nearly as pure as potatoes ; but these do not grow
wild

wild in a quantity sufficient to render them of account, neither have they been cultivated. Various other roots of different natural classes grow in warm countries, with moderate cultivation, such as yams, sweet potatoes, &c. which contain farinaceous matter in such quantity, as that the other substances may also be washed away, and starch be left. These contain a larger proportion of sugar than those we have already mentioned.

These are the sources from whence farinaceous matter is obtained for nourishment.

There are several substances which are contained in a variety of different vegetables; which, nevertheless, when extraneous matters are separated from them, so that they are obtained by themselves pure, are found to be the same species of matter. Thus it is the same sugar which is contained in all plants. It is the same blue matter which affords, with a mixture of yellow, the green

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in the leaves of all vegetables. So from whatever source farinaceous matter is derived, it has always the same properties.

It consists of a mucilage, combined with water so as to form a solid. It seems to be deposited in very fine particles in extremely small cells, as appears by the fine powder it easily falls into when ground in a mill. If it was an uniform solid, the grinding would by no means produce so fine a powder. When the cells are destroyed by soaking it in repeated waters it falls into an extremely minute powder, without much trituration, which it could not do if it was in a solid mass; as in that case the outside only would be softened or dissolved. It is hardly soluble in water heated to less than 100° of Fahrenheit's thermometer, excepting some fermentation should take place in it. It dissolves in water in a heat from 160° to 180° forming a viscid solution. An heat above 180° coagulates it, whether it be applied to the farinaceous matter immediately, or whether it be applied

plied to a solution of it in water. It dissolves by long boiling in water after it is coagulated, and now forms a solution not near so viscid, adhesive, or tenacious, as it does when dissolved in a less heat than is sufficient to coagulate it.

Farinaceous matter is perhaps the principal nourishment of mankind; and not only of mankind, but of other animals whose organs of digestion approach near to those of the human species,

Yet men do not use this substance without preparation, even after they have had the necessary labour of cultivation; for in all countries, where fire can be procured with any tolerable ease, they have always coagulated it by heat, and sometimes more firmly by alkohol, alum, and other substances, which have the power of coagulating it as well as heat.

The next substance taken from vegetables, which men use for nourishment, is sugar.

This substance is found in every vegetable, excepting the fungi, if they be vegetables. It must also be observed, that there is no evidence of its being contained in lichens, mosses, or algi, although from their taste one would be led to believe that it is also contained in these. I have procured pure sugar from a great variety of the different classes of plants: from the gramina, liliacea, plantæ, palmæ; from trees, shrubs, and herbaceous vegetables; from each of them of various natural classes, so that I have no doubt but it may be procured from all of them.

The process is easy: take any of the parts of an annual which are growing; or in a perennial take the juices at the time it is making its annual shoot; the quantity of juice to be collected must be several gallons, mix it with an equal quantity of a saturated solution of lime in water; boil them together briskly, taking off the scum as it rises, until the heat of the boiling liquor is 234° of Fahrenheit's thermometer; let

let it cool slowly, and crystals of sugar will often be found at the bottom. If they are not, mix the mass with the same quantity of the lime water, and evaporate it again : if crystals of sugar are not now formed, the mixture and evaporation are to be repeated, and the evaporation continued till the heat is from 244° to 246° . It is immaterial that the boiling should go on very quickly.

But although sugar is thus found in all vegetables, yet its sources for the purposes of food are not very general, being confined principally to grapes, figs, dates, and some other fruits. Fruits indeed in general contain sugar ; many of them in sufficient quantity to afford considerable nourishment. But the three species which I have enumerated, are those on which many persons live almost entirely, the sugar being nearly their only nourishment ; as dates in some of the African provinces, grapes in some parts of Portugal and Spain, and figs in parts of Greece, and the Grecian islands. I do not say that

in these countries all the inhabitants live upon these fruits alone, but many do.

In these fruits there are mixed with the sugar the vegetable mucilage, prone to fall into fermentations itself, and to carry the sugar as well as other matters along with it into fermentation, as appears clearly, by taking a solution of pure sugar, and a quantity either of the juice of the fruit in its recent state, or an infusion of it when dried, and putting them under the same circumstances, i. e. in a heat of 55 degrees, and a moderate exposure to the air; we find that the recent juice or infusion of the fruit will enter readily into fermentation, while the solution of the pure sugar will remain unaltered.

Both farinaceous matter and sugar are contained in the roots of umbelliferous plants, and receptacles of the flowers of the synginesia.

Sugar when purified, that is, separated from all extraneous matter, is a mucilage, capable of combining with water so as to form

form crystals, which are readily soluble in nearly half their weight of water, in a heat of 50° of Fahrenheit's thermometer, forming a viscid solution, which is readily diffusable through any quantity of water, in any heat the water will bear.

Expressed oils found in vegetables are also capable of being digested. The feeds containing them, and especially nuts, are in many instances the principal food of the inhabitants of a country, as cocoa nuts for instance, both in America and in the East. It is true that these feeds likewise contain farinaceous matter; but then the farinaceous matter is not nearly in such proportion as to give nourishment alone in the quantity made use of.

I shall have occasion to bring forward this subject more fully afterwards.

The next substance which is found in vegetables, capable of giving nourishment to mankind, is gum.

Under the name of gum almost all vegetable substances have been sometimes included which are perfectly colourless, insipid, and inodorous in themselves ; and which, when the juice of a plant oozes out naturally, upon the water's evaporating, leave a solid which is insipid, inodorous, and colourless, and dissolves in water so as to form a viscid solution. But of these juices and substances there are several which do not agree. Gum tragacanth for instance, having many of the properties of farinaceous matter. Those which I mean to take notice of at present, are gum arabic, feneca, cherry-gum, and others which are similar.

These, when found naturally in the plant, are combined with water, forming a solution of a viscosity in proportion to the concentration of their solution. They are not coagulable by heat, as is the case with gum tragacanth, and others of that kind. They are, however, coagulable by some applications, such as lithargyrus acetatus. They differ from the mucilage disposed to fermentation, and the mucilage which prevents fermentation.

mentation at least in this quality, that they have neither the one nor the other disposition.

This mucilage is no where cultivated for food, or even collected; so that we should be apt to consider it as incapable of affording any nourishment, if it were not that it has happened that the caravans crossing the sandy deserts of Africa, over which they have brought gum seneca, have in many instances lost their way, exhausted their provisions, and been obliged to live on this gum for many weeks, having nothing else but water alone, and that even very sparingly; but we know that a man can hardly live without food for more than ten days.

Another colourless mucilage is contained in almost all vegetable juices, which is not only in itself very apt to fall into fermentation, but is also extremely powerful in leading other vegetable matters into fermentation, as I have already taken notice of.

This mucilage I have never been able to separate by itself, so as to investigate its properties ; nor have I been able to determine whether it be a digestible substance or not. But it has powerful effects in the digestion of every substance with which it is mixed, and which I shall have occasion to notice afterwards.

It is contained in every vegetable, and in every part most probably, but more particularly in the root, or what is the same, the stem of perennial plants, when the annual shoot is just about to be pushed out ; in the growing part of all vegetables ; in the flower ; and in that pulpy substance which envelopes the seeds and fruits. It is also in larger proportion in particular natural classes, such as the cruciform plants, or according to Linnè's whimsically named system, tetradynamia, and some others.

But there is also another mucilage, which is the very reverse. It is likewise combined with water in the vegetables containing

ing it ; but when it oozes out from a wound seems rather to concrete, and become solid by evaporation, as may be seen on breaking an unripe cucumber, and letting its juice ooze out. This substance resists fermentation ; whether it be digestible or no, I also have not been able to determine ; most probably, however, it is, since unripe fruits of the cucurbitacea are cultivated in some countries, as a principal part of the nourishment for a certain season of the year.

The next substance which we may suspect to be found in vegetables, and to be digestible, is native vegetable acid. But there are no good grounds for determining whether it be or not, only that it seems, as far as experiments loosely as they have been made in many points of medicine show, to prevent the sea-scurvy, when men have been obliged to live on salted animal food.

The fungi are a class of substances which some have rather considered as animals than vegetables. They certainly have solids not

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at all similar to those of any other vegetable, if they be vegetables. They are to be classed as food at least, certainly with animals.

These are all the substances which are found in vegetables that appear capable of giving nourishment to mankind, or even to have any power over the digestion, excepting by their effects on the organs of digestion considered as alive. For in the first place, the fibrous and membranous parts of vegetables are clearly not digested, let them be ever so tender or soft. That they are digestible by other animals I have already shown. I need only here point out what occurs to every man's observation, that they pass through the intestines without being decomposed; and never form in any country, or in any nation, any part of the food; otherwise why should many rude nations, such as the Indians, inhabiting several parts of America, be hardly able to keep up their tribes, when they have plenty of trees and grass to feed upon, if these would serve for nourishment. It would then be no inhumanity to send a colony to drive a part of mankind

mankind so wretched, as hardly to be able to subsist on the shell-fish that are thrown upon their shore, into the inland part of their country, where there are plenty of grass and trees, if they could but feed upon them. But such food cannot be digested in the human stomach, in consequence inevitable destruction and devastation must fall upon that race.

There are various mucilages contained in vegetables, which have medicinal properties, and are never used as food.

It is true that some plants, naturally endowed with juices totally repugnant to the human body, nevertheless by human industry have been cultivated, so as to destroy their noxious qualities, and render them proper for food, such as lettuce, cabbage, &c. But then the same culture absolutely destroys these juices which would be detrimental.

There are also many medicinal substances found in vegetables. These might act upon
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the stomach as medicines, and afterwards be digested and afford nourishment. But this does not appear to be the case, for they seem to pass through the system unaltered: jalap for instance given to the mother, will purge the infant. The astringent juice of madder enters into the blood-vessels, so as to colour the bones.

Almost all animals, in certain situations, afford nourishment to mankind, and may be esteemed not only at first sight, or on slight investigation, to have in them an infinite variety as food, but even on more mature and perfect attention to them, they do not appear to be so easily reduced to their simple species, as vegetables. However, I must endeavour to discriminate the several different substances found in animals and proper for food, or capable of being digested.

In the first place, the solid fibres of animals differ very little in their properties, as far as they can be investigated chemically.

They

They all consist of a mucilage, combined with water, for the calcareous earth and calx phosphorata which are found in bones are only deposited in interstices. This seems also true of the shells of fishes, although in these the calcareous earth is in much larger proportion. In so far as it is contained in either, it certainly gives no nourishment to the human body. When these substances, therefore are digested, it is the fibrous, or membranous, or cartilaginous parts which give the nourishment. The solids which give nourishment, therefore, as I have said, consist of mucilage and water. The mucilage is combined with the water in such manner as to form a solid, not diffusible through more water, if it be applied in a moderate degree of heat, without a fermentation taking place. They are all coagulable by heat, as well as by many other applications. When freed from all extraneous matter, they are colourless, insipid, and inodorous. There are many other chemical properties in which they

they also agree ; such as yielding, on a distillation by themselves, which has formerly commonly been called chemical analysis, empyreumatic oil of the same kind, volatile alkali, water, gas, inflammable air, &c. Yet they differ very much in their easiness of digestion, which seems to arise either from their consistence, readiness of solution, coagulation, or readiness of entering into fermentation, as I shall have an opportunity of stating afterwards.

All animal fluids consisting of coagulable mucilages and water, seem also capable of being digested. These however, are more various than the solids of animals.

The properties of the different parts of the blood, and of the other fluids of the human body, I have investigated to a certain degree long ago, and published the results of my experiments in the *Natural History of the Human Body*. There can be no doubt, but that these may be digested and afford nourishment ;
but

but so inhuman a practice as employing them for food is fortunately nearly banished from the earth.

The fluids of other animals differ but very little from these in their chemical properties.

First then there are the red particles of the blood, and similar particles in the blood of some animals excepting that they are not red. As these have never been separated from the other parts of the blood, and given by themselves, we cannot say that they are certainly capable of being digested; the probability however is great.

The coagulable lymph, a substance which becomes solid on extravasation, is certainly capable of giving nourishment.

The serum, consisting of a coagulable mucilage and water, is another part of the blood which is also capable of affording nourishment. There have been authors, who
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from a hasty conclusion from experiments which they have not seen, have confounded this substance with the coagulable lymph : but it is not my business to enter at present on that subject.

The white of an egg is perfectly similar in all its qualities to the serum of the blood considered separately ; for what we ordinarily call the serum, is the serum properly so called, and the solution of putrescent mucilage and neutral salts, neither of which yield any nourishment.

The mucus, whose properties I do not repeat now, is not proved to afford nourishment to man ; although being a colourless and coagulable mucilage, we have great reason to believe it may, as we have also of all other colourless and coagulable mucilages. The yolk of an egg undoubtedly is capable of digestion in the human body ; most probably, however, it has its colour from its essential oil : it is likewise a coagulable mucilage combined with water.

It

It appears clearly that the poisonous juices of several animals, which when they are infused into a wound, prove almost instantly fatal, may nevertheless be thrown into the stomach, not only of many other animals, but even also into the human stomach, without the smallest detriment. I myself knew a black servant of Mr. Pitt, an Indian merchant in America, who was fond of soup made of rattle-snakes, in which the head, without any regard to the poison, was boiled along with the rest of the animal.

The expressed oil of animals gives nourishment likewise undoubtedly; but as I have said before, I reserve the treating of this subject till afterwards.

These then are the substances, and their various properties, which are employed to form the fluids and solids of the human body.

These substances in the organs which I have described, and with the admixture of

the fluids which I have also enumerated, are converted into chyle, which is afterwards formed into blood.

It is not possible, without the cruelty of the Peruvian altars, to investigate the properties of human chyle by experiment. But in as far as experiment has as yet been carried, the chyle of quadrupeds, a natural class of animals in which it is necessary that we should rank mankind as far as he is not improved by culture, have chyle so similar as not to be distinguishable, not even in natural classes the most opposite to one another in their food, structure, or habits of life. The chyle of a dog or of a wolf differs in nothing, as far as can be observed by any experiment which has hitherto been made, from that of a sheep or of an ox. I do not recite the experiments I have made myself, or that have been made by others on this subject, it would run these lectures into an unnecessary and useless length; but they agree together perfectly in as far as experiments have been carried.

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The chyle consists of three parts ; a part which is fluid and contained in the lacteals, but coagulates on extravasation. Whether the vessels act upon it so as to prevent it from coagulating ; that is, so as to keep it dissolved in water and fluid ; or whether the fluid itself is alive, and coagulates by death in consequence of extravasation, is an argument which I shall not here enter into. The second part consists of a fluid which is coagulable by heat, and in all its properties that have been observed is consonant to the serum of the blood. The third part consists of globules, which render the whole white and opaque. These globules have been supposed by many to be expressed oil ; but this has not been proved. Neither has it been perfectly demonstrated that sugar is contained in the chyle, although it has been made very probable. What renders these points difficult to determine is, the very small quantity of chyle that can be collected from any animal, not more than an ounce or two, at the very most, from one, even of the largest animals. However, the part coagulating on extravasation, the part agree-

ing with serum in its qualities ; the globular part, which in some animals, but not in quadrupeds, exists without giving whiteness to the chyle alone, or along with sugar, form the essential parts of the chyle.

A great many substances may enter the lacteals along with the chyle, even solids reduced to fine powder. When indigo has been thrown into the intestine of a sheep, I have seen the chyle rendered quite blue : now indigo is not soluble in water, but is a solid reduced into a very fine powder. So musk gets into the chyle giving it a strong smell, and a great variety of other substances of various colours, various tastes, and various smells, each of them giving colour, or taste or smell to the chyle. Nevertheless the lacteals seem to possess some power of rejection, since green vitriol, either exhibited along with the food, or thrown into the intestine after the animal has been opened while chyle was forming and absorbing, gives no colour on infusion of gall being applied to the chyle ; nor if
galls

galls be thrown into the stomach along with the food ; or if an infusion of them be in like manner thrown into the intestine, when an animal is opened during the time that the chyle is flowing into the lacteals, do they give any colour upon a solution of green vitriol being applied to the chyle ; the galls might be supposed to be digested, but the green vitriol could not ; neither can we well believe that the galls could be digested when thrown into a portion of the jejunum of about a foot in length tied at both ends.

The lacteals, therefore, would seem to be ready to take in many things not digested, but not all. One would be disposed to believe that what was injurious to the system would be rejected by this power ; yet when we consider the great reason we have to believe that cantharides, mercury, and many other substances are absorbed by them, which certainly are in many cases deleterious, we cannot well ground any doctrine on green vitriol and galls not being absorbed.

The substances which I have above pointed out to be the essential parts of the chyle, are totally different in all their properties from farinaceous matter, as well as the greatest part of the other substances employed for food. A change consequently of the properties of the substances employed for food must take place in the organs of digestion, so as to convert the food into these different substances essentially contained in the chyle.

THE PROCESS BY WHICH THE FOOD IS
FORMED INTO CHYLE AND BLOOD.

I come now, therefore, to consider what is the process by which this change is produced, and by which the substances employed for food lose their qualities, and acquire the properties of the essential parts of the chyle.

A simple particle of matter considered by itself is allowed by all philosophers, or in
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other words, it cannot be conceived but that a simple particle of matter by itself is perfectly inert and incapable of change. It may seem to you, Mr. President, and the rest of this learned audience, and even to the least informed man of any who have entered into the paths of science, that this proposition is so true, so uncontrovertible, and so generally admitted, that it may be impertinent for me to bring it forward to ground upon it any argument in the consideration of digestion. Yet, nevertheless, I must observe, that most of those who have treated this subject, seem very much to have forgotten this maxim.

A simple particle of matter remaining the same, a substance cannot acquire new qualities, unless the Almighty should please, by his all-powerful will, to change its effects on other particles of different species. Two particles of matter, therefore, of the same species must have exactly the specific properties of one, only that the two will have them, if both their powers can be exerted

exerted on a third body at once, a double effect. But that effect can only be more forcible, not different. If we were to add a third, or a fourth, or an innumerable quantity of particles, the properties would still be the same, and only, if capable of being applied together, of greater, but not of different effect. A grain of lead being projected by the force of gunpowder, may penetrate the integuments of the head, but not the skull; but if four hundred and eighty grains are made into a sphere, and projected by a proportional quantity of the same matter, it will overcome the resistance of the skull also. If the ball consisting of four hundred and eighty grains be divided into balls consisting of a grain each, each of these balls will still have the power of penetrating, though with less force, and therefore will be capable only of penetrating through bodies making less resistance. In like manner any larger or smaller mass of matter of any species will have the same properties exactly, only that these properties, when they can be exerted

erted together, will have greater effect in a large mass than in a small one.

Let us take another exemplification of this subject. Suppose that we have a quantity of matter which is perfectly blue, every particle of it is blue; the blue rays of light which it reflects or transmits, strike the eye each with no other colour but perfect blue; it is seen more perfectly when there are several rays thrown from several particles so as to be formed on the retina at once; the substance impressing the mind with a stronger idea of a blue colour when the particles are numerous. But let us suppose for a moment that there is only one point in the retina sensible to light, then one particle of the blue substance reflecting one ray of blue light, would appear as blue as any mass, however numerous its particles might be, if the reflecting surface did not direct every ray to that point as a focus.

In like manner the smallest particle of vitriolic acid will have a disposition to affect
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the tongue so as to give an acid taste, although the effect may be so faint as not to be perceived. But the impulse of a number of particles acting on different parts of the tongue at once, will, by their accumulated powers, produce a sensible effect. So the smallest particle of vitriolic acid which can possibly, or does actually exist, will unite with a particle of iron so as to form green vitriol.

Division, therefore, unless it be such as separates two particles of different species of matter chemically combined, cannot change the properties of one species of matter so as to form it into another.

Although this doctrine is obvious and universally agreed to, yet it has been by no means so held up to light by those who have treated on the subject of digestion, as at all to govern the reasonings which have been held with regard to it; I shall, therefore, still put it in another light.

No

No mass of matter consists of one solid, uniform, perfectly compact body of matter; if it did, and remained unbroken, it would be always of the same bulk in every circumstance.

Moreover, the attraction of gravity being in all matter according to the quantity of matter contained in any mass, without consideration of the interstices, as has been proved by experiments on pendulums, the quantity of matter in a mass is according to its specific gravity. Now, if any space was quite full of matter, the mass would be always in specific gravity equal to the same bulk of any other species of matter, which is not the case; therefore a mass of matter consists of matter and interstices.

Further, if we take any mass of matter and expose it to a greater degree of cold, it contracts. If the particles of matter touched in any one direction, they could not come nearer one another in that direction, therefore the contraction would not be equal and uniform. But the contraction of any body, when it is equally cold, is exactly equal and uniform

uniform in all directions ; consequently the particles of matter contained in a mass come nearer, and therefore do not touch one another in any direction ; therefore, the matter contained in a mass is in separate particles, not touching one another in any direction.

A particle of matter must be considered in itself perfectly hard, because it cannot be pressed into a less space. If we have any idea of matter at all, the first and most absolute quality of it is to occupy compleatly and fully the space which it is in, admitting no other matter within that space. It is also most perfectly inflexible, for it could only be bent by one part of it being separated from another, at least in all points except those lying in one line.

Masses of matter, therefore, consist of a number of small particles not touching one another in any direction. When, therefore, one mass of matter acts upon another, the particles of one mass are not brought into contact with the particles of the other mass. If, therefore, one mass of matter should divide
another,

another, it must act by an attracting or repelling power. That is, if I apply an iron wedge to split a piece of wood, the edge of the wedge does not touch the wood, considering touch in a strict sense; but one side of the wedge, if the edge be a true line, repels one part of the wood to one side, and the other side repels the other part of the wood the other way, and so separates them from one another.

The idea which I have just laid down of masses of matter being in particles quite separate from one another, like many others which have perhaps originated with me, or perhaps with others that have not come to my knowledge, having crept through Europe, has occasioned another idea to be propagated on this subject, the imagination of mankind not always correcting itself by the strict powers of the judgment. Some have supposed that matter consisted of attracting and repelling points, not considering that a point is nothing, and of which, therefore, nothing can be predicated, or
nothing

nothing can have no qualities. It is the reverse of another imagination, viz. that matter is mind, which we shall leave at present to be discussed by metaphysicians, whose arguments, like a circle, have no end.

A mass of matter, therefore, consists of simple particles, every one of which has the exact determined specific qualities that the whole mass has, as far as these qualities differ from any other species of matter ; for, as an example, one single particle of water has exactly the same qualities that any other single particle of water has, and equally exerts them when it is put into a situation in which they can be exerted.

Dividing, therefore, any of the substances we employ for food into its smallest possible parts or particles, cannot alter its qualities in the smallest degree, so far as it has specific properties. The smallest particle, therefore, of farinaceous matter, suppose that it was divided into its smallest particles,
cannot

cannot have a different property or properties from those of farinaceous matter, and cannot therefore, by division, be converted into that part of the chyle which coagulates on extravasation, nor that part which is coagulable by heat, nor that part which we find in globules, much less into all these three parts; yet it is actually in digestion converted into all the three. That trituration, or dividing the food into small particles, is the means of converting food into blood, is an opinion perfectly impossible to be true, and therefore not worth searching after by other experiments or arguments than those I have adduced.

Modern times are those of experiment. It is true that all our knowledge of every thing whatever must arise from experiment only, that is, from the evidence our senses give us of what appearances nature, in other words, the creatures of the Almighty, give impressions of. Some of these impressions are received from the ideas that arise from things not at all under our dominion,

or from circumstances which he governs himself. Thus, for example, a man sees a tree lose its leaves in the autumn, sees them renewed in the spring, and a new growth take place during the summer; he sees the blossoms open in the spring, these he finds followed by fruit, which if it falls into the earth, he finds capable of producing new trees of the same species, or he sees it gathered by animals and affording nourishment. In this mode of acquiring knowledge man is totally passive; he did not contrive to make leaves fall in the autumn, and be re-produced in the spring; he did not contrive to make new wood grow in the summer, nor that blossoms should open that the seeds should be impregnated with the embryo; he did not contrive that the fruit should grow, nor did he teach animals that it was fit for their nourishment. What knowledge is acquired by attention to these natural circumstances has been called observation. It is indeed a contemplation of the benevolence of the Almighty to give nourish-

richment and happiness to all the inhabitants of the earth.

The minds of mankind, not satisfied with their powers of observation of what passes in this earth, but being forced even for their own subsistence to exert themselves far beyond the brute creation, are necessitated to make a farther enquiry, and that with a labour beyond the contemplation of the benevolence of the Almighty. To those creatures who have only this earth to exist in, food and raiment are provided without labour or attention during the short period of their lives. It is not sufficient for the farmer to look where grain grows naturally; it is necessary to try, with an infinite variety of applications that may be made to the ground, to produce crops superior to those which would arise in it without any cultivation. It is necessary for the hunter not only to observe the natural history of wild beasts, but also to try by what means he can engage them to fall into his toils. It is necessary for the fisherman, besides

admiring the multiplicity of fish, to be able to contrive either to entangle them or surprise them into his nets. It is necessary for the shepherd to try by what means he can increase his flocks, so as to produce greater numbers than would naturally be propagated. It is necessary that man should try to procure better defence from the inclemency of the weather, than the caverns and other hollows of the ground which naturally offer themselves. So, and in many other cases it is necessary for mankind, not only to contemplate those things which happen naturally, but likewise he is constrained to form projects of his own, and to contrive means of putting both mind and matter in circumstances foreign to what would naturally arise in them, and contemplate the effects; and this we call experiment.

Observation then, and experiment, are the sources of all the knowledge of mankind.

Man seems to have a degree of pride implanted in his nature, which prompts him
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constantly to consider himself as being far superior to what he actually is, and which instinct is the surest proof that he is to be very superior indeed. But as all the virtues of mankind are balanced by opposite imperfections, the pride of experiment has in many instances thrown science into confusion, instead of forwarding it. An experiment to prove a thing otherwise demonstrable is totally superfluous; and not only superfluous, but fallacious. It is perfectly clear, that if a tube be filled, and kept constantly full of a fluid, and placed perpendicularly, having three equal holes pierced through it, and that one shall be in the middle of its height, the others at an equal distance from it above and below, that the fluid flowing through these holes should all be carried to an equal distance. Yet upon trying the experiment, it never succeeds without management, because of the imperfection of the workman, and materials. Experiment, therefore, is often employed only as illustration, and not as a foundation of science.

This digression perhaps was not necessary to confute the idea that trituration could have any effect in changing food into chyle, if it were not to excuse myself from taking notice of the futile, unnecessary, and inconclusive ground that some modern authors have taken for the explanation of this subject. I conclude the argument with this assertion, grounded on what I have now said, that if any or either of the substances employed as food were divided into their smallest possible particles, they would remain still in all their specific properties exactly the same as they were when they were thrown into the stomach, and would never be converted either into chyle, or into blood. That no experiment, or course of experiments can be made to render this proposition more or less evident, and that therefore all the experiments which have been made with regard to this proposition are perfectly futile.

I come in the next place to consider another idea which has been held with regard to

to the operation which goes on in the digestion of the food, to wit, that there is some menstruum found in the stomach, which unites with the substances employed for food, and forms the different essential parts of the chyle. That is, for example, that farinaceous matter is capable of uniting with such menstruum, so as to form the part coagulable on extravasation, the part coagulable by heat, and the part which appears in a globular form.

This opinion is undoubtedly a possible one, and can only be determined to be true or not by experiment; for, there may be either three menstrea in the stomach, which may unite with farinaceous matter, so as to form the three different compounds of which the chyle consists, or there being one menstruum, it may unite in different proportions with the farinaceous matter so as to form these substances. As muriatic acid and mercury are capable of forming corrosive sublimate and calomel, the acid and the

mercury being in different proportions in the one and in the other.

Farther, the three parts of the chyle may be contained in the farinaceous matter ; and the compound may be such as that there may be a substance found in the stomach which may unite with one of the elements of the farinaceous matter, and set the three parts of the chyle loose.

There is one observation I here beg leave to make with regard to a mode of reasoning which has been too often adopted in physiology and medicine, to wit, that it has frequently been thought sufficient to prove that a thing was not impossible, in order to ascertain its actually being true. Thus, for instance, it has not been proved, or attempted to be proved by any experiment, that there is any substance found in the stomach capable of uniting with farinaceous matter, or any of its elements, so as to form any of the parts of the chyle, nor that there is any substance ever found in the stomach capable

pable of precipitating the parts of the chyle from farinaceous matter. On the contrary, the coagulating gastric juice, instead of uniting with farinaceous matter, so as to form chyle, has a tendency to coagulate it, if it be not coagulated before it is thrown into the stomach. The mucus unites with farinaceous matter, so as to form a thick paste, resembling in properties the parts of the chyle in no way, and the watery juices of the stomach unite with farinaceous matter, so as also to form a paste likewise in no way similar to the constituent parts of the chyle. Nor have bile, or pancreatic juice, any effect upon farinaceous matter, excepting for the water they contain. Nor do any of the fluids of the stomach or duodenum appear from any experiment that has been made either to unite with, or precipitate from farinaceous matter any thing like the parts of the chyle ; but on the contrary, they either form a paste with it, or have a tendency to coagulate it.

Farther, the properties of farinaceous matter, and the matter of a muscular fibre,
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are totally different, so as to be actually two distinct species of matter. Now, although the menstruum in the stomach might unite with one of them, so as to form the constituent parts of the chyle; yet the same menstruum could not unite with another solvent, consisting of a distinct species of matter, so as to form the same compound. Vitriolic acid, for instance, may combine with iron, so as to form ferrum vitriolatum, commonly called green vitriol; but vitriolic acid can never unite with copper, so as to form the same ferrum vitriolatum, but will unite with it so as to form quite another compound, to wit, cuprum vitriolatum, commonly called blue vitriol; but which is totally different in its properties from the ferrum vitriolatum, excepting in those properties which it enjoys in common with other metallic salts.

Now the three parts constituting the chyle are exactly the same, whether the matter of a muscular fibre or farinaceous matter be digested; for I have fed a dog with farina-
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aceous matter, and another with the matter of a muscular fibre, and opening them both during the time the chyle flowed through the lacteals, collecting as much chyle as could be collected from each, on examination of their properties, they both consisted of the three essential parts I have already enumerated, each of these parts in the one was perfectly similar, as far as I could contrive any experiment, to those of the other. Whereas if it had been a menstruum which united with the farinaceous matter, and the menstruum had united with the matter of the muscular fibre, the parts of the chyle formed from the one and the other must have been exceedingly different, as the *ferum vitriolatum* is different from *cuprum vitriolatum*.

Moreover, in like manner, the properties of the parts of the chyle ought to be different when any one other of the several species of matter which may be employed for food is used; but that is by no means the case. The chyle of a cat, for instance,

or

or a dog, wholly living on animal food, is the same with, and cannot be distinguished from the chyle of an ox or sheep living wholly upon grass.

I will still add another argument to elucidate the point, whether chyle can be formed by solution or precipitation.

There is no menstruum that is capable of acting on any solvent, but may be applied to it in circumstances out of the body of a living animal, so as to dissolve or decompose it. But if we apply the gastric, or any other of the juices which are applied to the food in the stomach or duodenum, we cannot by any means form chyle out of the body. The gastric juice will coagulate substances out of the living body as well as within it; the bile will neutralise an acid out of the body as well as in it; but by applying coagulating gastric juice, the watery fluids of the stomach, the saliva, the bile, the pancreatic juice, altogether or separately, in no case.

case has chyle or any thing like it ever been formed.

Although, therefore, it is possible that a menstruum might have been produced in the stomach, which might have united with one species of food, so as to have formed the different parts of the chyle, in which case an animal could have lived on one species of food, which is actually found to be the case; yet the same menstruum could not have been combined with another species of food, so as to form the three parts of the chyle, which are always the same in each of their properties. Moreover any of the juices which are applied to the food in the digestion, or all of them together, may be applied to the food in circumstances perfectly similar, as far as regards solution or precipitation, and yet no chyle can be formed.

On the whole, therefore, there is not the smallest ground from experiment to affirm, that there is any juice or matter applied to the food in the stomach capable of,

or actually uniting with any or all of the substances employed for nourishment, so as to form chyle. Neither is there any ground for believing that the chyle is precipitated out of the substances employed for nourishment, and therefore this idea of the formation of chyle ought to be abandoned for want of proof. But it not only wants proof, but every kind of appearance renders it perfectly improbable, and therefore we must search for some other operation, by which the substances employed for nourishment can be converted into the three essential parts of the chyle.

Another idea which, as well as the two we have already gone through, has been taken up during almost all ages, is, that vegetable substances in order to be digested would go through the vinous and acetous fermentations, and the first stage of the putrefactive, so as to be formed into a mucilage, which, if it proceeded in putrefaction, would produce the same substances that any animal mucilage produced when it putrefied,

trefied, and was therefore animalized as it was called ; and that animal substances also went through the first stage of putrefaction in the digestion. This opinion is held still in a greater or less degree by many physiologists.

The ground of this opinion is, that if we take a quantity of vegetable substances, of almost any species, put them in a bag similar to the stomach, or into a dead stomach, keep them moistened with water in the heat of the human body, that is in a heat of about 98° of Fahrenheit's thermometer, and in constant motion, that is to say, in circumstances as nearly similar as possible to those to which they are exposed in the stomach, a saccharine, acetous, and vinous fermentation takes place, or at least the acetous fermentation, acetous acid being certainly produced, afterwards the mass putrefies, and by the first putrefaction vinegar is converted into a mucilage.

There

There being no ground on which we should suppose that there is any difference between vegetable matters contained in a living stomach and a dead stomach, under the circumstances that have been pointed out, it was supposed to be proved by experiment, that the saccharine, vinous, and acetous fermentations, and the first stage of the putrefactive, actually took place in a living stomach.

Farther, we find it happen frequently that a quantity of acid is brought up by vomiting ; which acid being saturated with kali, that is, what was formerly called fixed vegetable alkali, produces kali acetatum, formerly called regenerated tartar, or sal-diureticus. This observation appears to confirm by experiment the doctrine of the same changes happening in the living and in the dead stomach. But there are great grounds for controverting this opinion, so strong as in my opinion to render it totally inadmissible.

In

In the first place, the situation of many of the fluids in the human body, and those of other quadrupeds, and even in almost all animals, is in many cases nearly the same with those we can put them into out of the body of a living animal, and yet the same changes do not take place. For example, the blood does not putrefy in the vessels of a living animal, although if contained in the vessels of a dead animal in the same heat, and in all other circumstances as similar as possible, it putrefies in a few hours. The coagulable lymph remains fluid in the vessels of a living animal, but coagulates immediately on extravasation.

This gave me a ground of doubt, whether the same changes took place in the food in the stomach of a living animal, that did in the same circumstances as far as they could be copied, excepting not being in the stomach of a living animal. I therefore gave several dogs meat alone, and killing them in about four hours afterwards, on examining the substances at the beginning of

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the duodenum I found no acid, or at least not any that could be traced by the change of colour of vegetable juices. I gave to other dogs in like manner bread by itself, and bread along with meat; on examining the matter after about the same length of time, that had passed into the beginning of the duodenum, I found in both cases that there was not a sufficient quantity of acid to change the colour of the juice of violets, but upon applying the juice of black cherries, the brightness of the red that immediately ensued, showed evident acidity. One thing farther suggested itself, that bread was not the natural food of the animal on which the experiment was made; that therefore some small portion of this vegetable substance might be not perfectly digested, but elude the powers of the stomach, and go into the same fermentations it would have done in circumstances nearly similar out of the body. I still doubted whether formation of acid was any part of the digestive process, and therefore conceived the idea of examining the fact in sheep and

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cows,

cows, whose natural food is entirely vegetable. On examining the matter in the beginning of the duodenum in these animals, I did not find the least trace of acidity, it not altering the colour of red cherry juice, the lithmus, nor any other vegetable juice, of which I tried several. Mr. Hunter, occupied always in experiments, equally well conceived and accurately executed, had much about the same time or before found no acid in the previous or digestive stomach of rabbits, and other animals of the same kind. I am led to conclude, therefore, that the formation of acid in the stomach during digestion, is always produced by the digestion not going on perfectly, the powers of the stomach not being sufficient to overcome the disposition of vegetable substances to run into the saccharine, vinous and acetous fermentations, and that when the organs of digestion are weak or disordered, or when we give an animal food not adapted to its organs of digestion, a greater or less portion of the food is not governed by the stomach, but runs into the fermentations

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which would arise if they were not influenced by its power.

Another point is still to be taken into consideration for the elucidation of this argument.

The mucilage produced by putrefaction is in no way similar to either of the three constituent parts of chyle. If we take vinegar and place it in a heat of 100° of Fahrenheit's thermometer, a film forms on its surface, which, when it becomes of a sufficient degree of thickness, falls to the bottom, and a fresh film begins to form, and goes on in the same manner. This film consists of a mucilage and water, which does not dissolve in water without going through farther change. There is also another mucilage produced, which is soluble in water, and not coagulable by heat. Now neither of these mucilages is any way similar, either to the mucilage of the chyle, which is coagulable on extravasation, or to that mucilage which oozes out from it, or to the globular particles; therefore, the first stage

stage of putrefaction does not form vegetables into chyle, much less does the first stage of putrefaction form animal substances into chyle; for if meat be exhibited to a dog which is already fœtid and tender from putrefaction, and the dog be killed in half or three quarters of an hour afterwards, and the meat in the stomach examined, it is found firmer and free from fœtor, so far is putrefaction, or any of its stages, from being the operation carried on in the stomach during the digestion.

The changes which take place in the substances capable of giving nourishment, and therefore of being converted into the three essential parts of the chyle, are totally different from those changes which take place any where but in the stomach, duodenum, and jejunum when alive, therefore no experiment made any where, excepting in these intestines in the living animal, can in the smallest degree influence the doctrine of digestion. It must also be farther observed, that when food is thrown into a stomach not

in perfect health, no conclusion can be drawn from any substance produced by any change of the matters thrown in, for we have already seen that in a stomach not in health, there is not sufficient power to correct the acescency of vegetable food. So in like manner we find in a stomach not in perfect force, that animal food will putrefy, although in a stomach in perfect force, not only putrefaction will not go on, but will be even stopped, and the appearances of it destroyed, as in the experiment before recited. Farther, we find that men unaccustomed to live on animal food alone, if they are fed with such food, especially if it be salted, will have putrefaction in many instances produced in their fluids, although men, such as the inhabitants about the mouth of the Orange River, in Africa, live always on animal food, such as whales, seals, limpets, and what fish they can catch; that many times their food has entered into a great degree of putrefaction, and there is no vegetable food whatever employed at the same time; probably
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most of them never tasted any vegetable substance in their lives, excepting aromatics for seasoning; yet they are perfectly healthy and free from all putrefaction in their fluids or solids, though they are not very careful of avoiding it in the exterior parts of the body. We see likewise maggots live in and upon putrid masses, while they themselves and all their fluids are perfectly sweet and free from all appearance of putrefaction. Experiments to be conclusive with regard to the digestion must be made not only in stomachs which are alive, but they must be in perfect health and vigour, and even food must be exhibited, for which they are naturally formed, and nothing must be introduced which may put them into disorder, or alter their action on the food.

If we examine all the experiments that have been made on this subject according to this rule, we shall find most of them somewhat similar to the experiment proposed by the late Dr. Johnson, to wit, to mix the water from the famous pump in the Temple

with that of the cisterns in Grand Cairo, to explain the generation of gold. Accordingly we find nothing but eternal vagueness and uncertainty of opinion on this subject.

It may perhaps, however, be possible to draw some conclusions from whence some useful elucidations may arise, from observing what happens in sound and healthy stomachs on the digestion of the food.

First, we see that one substance, farinaceous matter, is converted into another substance, chyle. Farinaceous matter forms one species of matter only; chyle consists of three species mixed together. Let us consider what is the operation by which one species of matter may be converted into the three other species.

It is impossible to conceive that the Almighty is constantly annihilating the attractions and repulsions of bodies, and giving them new attractions and repulsions.

We

We find that by combining two species of matter together, each of them loses its particular qualities, and gains properties entirely independent of the properties of either of the substances of which it consists, excepting when another species of matter is applied which has a greater disposition to unite with one of the two substances of which it consists, and therefore actually does combine with one of them, forming with it also a species of matter totally different and distinct. As for example, vitriolic acid combines with iron, so as to form a new substance, ferrum vitriolatum, which is in all its properties perfectly different from either vitriolic acid or iron. The properties of the ferrum vitriolatum are not only different, but absolutely independent of either the properties of the acid, or the properties of the iron, excepting we apply zinc, which has a greater disposition to unite with vitriolic acid, with which it does actually unite, and separates the iron, forming with the acid zincum vitriolatum, ordinarily called white vitriol, which is a new and

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perfectly

perfectly distinct species of matter. It is clear, therefore, and indeed since the time of Mr. Boyle's making this discovery has been gradually making its way, and is an universally received opinion, that the properties of compound bodies depend upon their combination, not upon the properties of their elements. It is farther to be remarked, that two substances may be combined together, so as to form a third which may be considered as an element capable of uniting with another element, so as to form a compound also perfectly new in its properties. For instance, muriatic acid may unite with ammonia pura, or as it has been called, caustic volatile alkali, so as to form ammonia muriata, formerly called common sal-ammoniac; and this ammonia muriata may unite with the calx of copper, so as to form a blue salt, perfectly different in its properties from the muriatic acid, the ammonia pura, the ammonia muriata, and the calx of the copper, *excepting as has been before excepted*. In this combination the calx of copper is not united with the
muriatic

muriatic acid, or with the ammonia pura, but with the ammonia muriata, as is clear, because if we unite the calx of copper with the muriatic acid, the ammonia will separate it, therefore ammonia and calx of copper cannot be united with muriatic acid at the same time. So in like manner, if the calx of copper be combined with the ammonia; if we apply muriatic acid, the muriatic acid will unite with the ammonia, and separate the calx of copper from it; so that ammonia cannot be combined with muriatic acid and copper both at the same time; and therefore the calx of copper must be combined with the ammonia muriata considered as an element.

If we have three species of matter, and take one particle, or smallest integrant or possible part of each, which smallest integrant parts we shall call A, B, C; A may unite with B, and form a compound M, which may unite with C, and form a compound particle X; or, A may combine with C, and form a compound N, which may combine

combine with B, and form a compound particle Y, and B may combine with C, and form a compound O, which may combine with A, and form a compound particle Z; therefore the compounds X, Y, Z, contain in them the same matter exactly, to wit, one of the smallest integrant parts A, B, C, of three distinct species of matter, and these three compounds differ from one another, therefore, not in their elements, or substances of which they consist, but in the manner in which they are combined. We have here then an operation which may possibly take place, by which one species of matter may be converted into another species, so that the whole matter in the one species may all be contained in the other species, and that without any addition of any other matter whatever.

Again, supposing we have four particles of matter, A, B, C, D, these four may be combined into one: that is, A may combine with B, so as to form M; and C may combine with D, so as to form N; M and

and N may combine together, so as to form one compound X; this compound may be decomposed, so that A may combine with D, and form a compound O, and B may be combined with C, and form a compound P, which compounds O and P may not be capable of combining together; so that from the compound X, two other compounds, O and P, may be produced; therefore from one substance it is possible that two others may be produced containing exactly the same matter, and without the addition or application of any other substance to it.

If we find, therefore, when one species of matter is converted into another species, that the same elements are contained in the matter which we had originally, and the matter which is found after the operation, it cannot be doubted but that the operation which has taken place, is a separation of the elements from one another, and a recombination of them in a new manner. The farinaceous matter contained in barley is

is converted into sugar without any addition or application to the farinaceous matter ; but barley and sugar contain the same elements ; we may, therefore, conclude, that it is by this operation that this conversion takes place.

That barley and sugar contain the same elements is shown in this way. It must be admitted that any compound, when pure, always contains the same elements. Thus kali nitratum, or as it is commonly called, nitre, consists of kali and nitrous acid, and every particle of nitre consists of these two elements, so that whenever we have nitre, we are sure to have kali and nitrous acid,

Farther, therefore, if we put the farinaceous matter of barley into a glass retort, and distill it by itself, we obtain empyreumatic oil, an acid, and water distilled over, and there remains behind charcoal. If we put sugar into a retort and distill it by itself, we also obtain the same empyreumatic oil, water, and the same acid, and there remains behind charcoal similar in all its properties.

perties. We get, therefore, four substances, to wit, empyreumatic oil, water, an acid, and charcoal, from the convertible substance farinaceous matter, and the substance which it is converted into, to wit, sugar. If these four substances be the most simple elements, then farinaceous matter and sugar are constituted of the same substances or elements. Or if any or each of these four substances be compounds, being the same when procured from farinaceous matter, and when procured from sugar, they contain the same elements. Farther, that the change of the farinaceous matter into sugar is by the elements being separated from one another, so as no longer to be combined in the manner that they are united in farinaceous matter, but that they are separated from one another, and re-combined in a new manner, so as to form sugar a new compound*.

In like manner a piece of a muscle being thrown into the stomach, and passing through the organs of digestion, is con-

* The vapours obtained are here neglected, but they are also the same from both.

verted into chyle; for the muscle and the
 chyle both contain the same elements, as is
 proved in like manner, by putting the
 muscle into a retort, and distilling it by it-
 self, there will come over empyreumatic
 oil, volatile alkali, and water, there will
 remain in the retort charcoal; if we also put
 chyle into a retort and distill it by itself,
 there also come over empyreumatic oil, vo-
 latile alkali and water, there remains in the
 retort charcoal. The empyreumatic oil,
 volatile alkali, water, and charcoal, which
 are procured from the muscle and from the
 chyle, are perfectly similar to one another
 in all their qualities, as far as can be investi-
 gated by any experiments that could be con-
 trived. If therefore these four substances
 be simple species of matter, the muscle and
 the chyle contain the same elements; the
 only difference is, that these elements are
 combined together in a different manner.
 Or if the empyreumatic oil, volatile alkali,
 water, and charcoal, are not themselves
 elementary, still these consist of the same
 elements; that is, the empyreumatic oil
 from

from the muscle contains the same elements with the empyreumatic oil from the chyle; the volatile alkali, water and charcoal, in like manner contain the same elements, whether they be obtained from the one or the other, or if they were obtained from any other substance whatever.

It appears then that the muscle and the chyle do not differ from one another in any other respect, excepting that the elements of which they both equally consist, are united by one mode of combination in the muscle, and in another mode of combination in the chyle. That the conversion, therefore, of the muscle into the chyle is a separation of its elements from one another, and a recombination of them in a different manner, so that the compound shall have new properties.

By a parity of reasoning it may be proved, that all animal food in being digested or converted into chyle, has the effect produced by a separation of its elements from one an-

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other,

other, and recombination of them in a different manner, so as to form chyle, a new compound; and likewise, since by putrefaction farinaceous matter, and all other vegetable food may be made to yield exactly the same substances with animal substances, particularly with chyle; that is, nitrous and muriatic acids, volatile alkali, water, volatile hepar sulphuris, gas, inflammable air, calcareous and argillaceous earths; as these are the same, whether vegetable food or chyle be putrefied, it follows that vegetable food likewise contains the same elements with chyle, and that these elements are only separated from one another, and recombined in such manner as to produce and become chyle.

Digestion then is performed on substances containing all the elements of chyle. These substances in the stomach, and other organs of digestion, have their elements separated from one another by the effects of the stomach, and other organs of digestion, upon them, occasioning in them a decom-

decomposition and recombination of their elements into a new substance.

Supposing that I have proved that food is not formed into chyle, by being combined with any watery or other menstruum, by being rubbed down into fine particles, or by undergoing any part of the saccharine, vinous, acetous, or putrefactive fermentations, but by a decomposition and recombination of the elements of the food which requires no additional matter, nor that any should be taken away, can any advantage be drawn from so abstracted an argument?

We are now to endeavour to understand by what power a compound may be decomposed, and its elements reunited in a new manner.

Every person, in the smallest degree acquainted with the principles of chemistry, knows that changes are produced on bodies

by their dispositions to unite with one another, which we call their attractions: Supposing then we have three substances combined with one another in a certain manner, but there is another mode of combination, in which they are more disposed to combine, in consequence of their attractions, in that case we might expect that they would separate from one another, and combine according to the mode of combination they were most disposed to, and therefore they would immediately change their combination, and in consequence their properties; that therefore if the substances of which a muscular fibre consists, had a greater disposition to unite with one another in the manner that they are combined in chyle, than in the manner they are united; then a muscle would always and immediately be converted into chyle, in whatever circumstances it is placed, and that therefore a muscle could not exist for a moment of time, but would always and immediately become chyle.

It

It is to be observed, however, that when two substances have a disposition to unite with one another, or to decompose one another, it is not sufficient that they should have this power; it is necessary also that they should be put into certain circumstances in which the powers of combination and decomposition are capable of acting. Thus, for example, nitre and sal-ammoniac, or according to their present names, kali nitratum, and ammonia muriata, being rubbed together to a fine powder, do not affect one another, nor do they affect one another if they be dissolved in water; but if we melt them together, they decompose one another, nitrous acid uniting with or decomposing the ammonia, and flying off, and the muriatic acid uniting with the kali. The circumstance of fusion is necessary to make the elements of these two neutral salts exert their powers of decomposition and recombination. That, however, is not the case in other instances; for ammonia vitriolata, and natron muriatum, or as it is commonly called sea-salt, being dissolved in water, will decompose

one another, the vitriolic acid uniting with the natron, or fossil alkali, as it has been called, and the muriatic acid with the ammonia, or volatile alkali.

So in like manner, vitriolic acid poured upon mercury in the cold, will not combine with its calx; but if heat be applied, that circumstance will make the combination take place, and the inflammable air be extricated and decomposed.

Thus also sugar dissolved in water, and kept in a heat of 40° of Fahrenheit's thermometer, will not have its elements separate, and recombine into wine. But in the same manner the action of the powers of the stomach, and other organs of digestion, upon the food is necessary for those powers which occasion its decomposition and recombination to act. So that although they are always present in the substances capable of being converted into chyle, yet nevertheless they are not exerted, unless they are influenced by the action, or circumstances which they meet with in the organs

organs of digestion of a living animal; so that no chyle ever has been, and most probably never can be produced, excepting in the organs of digestion of a living animal.

It would lead me far beyond my present subject of enquiry to enter into the powers which the living body has over the matter of which it consists, and which it contains. Proof, however, might easily be brought, and has been, that under the same chemical circumstances matter differs extremely when living and dead. Food placed in all the chemical circumstances that can be conceived similar to those in which it is placed in a living stomach, will never be converted into chyle, but will undergo other changes totally different. Animal food will putrefy, vegetable food will become acid, and therefore when food is thrown into the stomach, there is a constant contest between the disposition to the change that it would undergo in similar chemical circumstances, but not in a living stomach, and the changes it is disposed to undergo by the action of the

living organs of digestion upon it. If the living power of the stomach be strong, it will be perfectly digested; if the living power of the stomach be weak, it will not be perfectly digested; but part of it will undergo those changes it would have undergone, if it had been in the same chemical circumstances, but not acted upon by the living organs of digestion. Thus we see, when the stomach is strong, all species of food readily digested and converted into chyle; while in weak stomachs, if too large a quantity of food be employed, or food which does not easily enter into the digestive processes, or food which the stomach has not been accustomed to act upon, it will in part, or in some cases wholly, be converted into matter which must either pass through the intestinal canal, or passing into the blood vessels along with the chyle, must be gotten rid of by some process which requires the exertion, and therefore exhausts the powers of the system. Or it may be even converted into substances which are noxious to the stomach and intestines themselves; as for instance,

stance, it may be converted into an acid which produces heart-burn, vomiting, &c. Or its effects on the organs of digestion may be noxious to the whole system, as undigested animal food may putrefy while it remains in the stomach, and by its operation on the stomach produce fever, which has been called violent, putrid, malignant, &c. of which I have known more than one instance. Or the food not being digested, may be converted into matter, which entering into the blood vessels along with the chyle, may, while it remains, have bad effects on the whole system; as men living on salted animal food for the principal part of their nourishment, without being accustomed to it from their infancy, or for a long time, and without a sufficient mixture of herbaceous vegetables of loose texture, will have putrescent matter carried into their blood vessels along with the chyle, which will so depress the powers of the system as to make them incapable of overcoming entirely the disposition to putrefaction, which the blood would be thrown into were it left
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in those chemical circumstances in which it is in the blood vessels, were it not alive in itself, or acted upon by vessels having a living power.

This reasoning, therefore, leads me to lay down this rule. That, in the first place, food, which for any of the reasons already alledged is not digested, never produces any nourishment, and that therefore all the mischief that arises from its indigestion affecting the organs of digestion themselves, all the bad effects of noxious matter produced and acting upon the system, all the bad effects arising from noxious matter getting into the blood vessels along with the chyle, besides all the loss of the powers of the system exerted to get rid of the undigested food, if even it be not converted into noxious matter, are all suffered without the smallest advantage. This argument, therefore, concludes in this maxim, that neither in health, nor more particularly in disease, should food ever be used in a greater quantity, or of such quality as cannot be
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made by the powers of the stomach, and other organs of digestion, to enter into, and go through that process which converts it into the three essential parts of the chyle.

On the other hand it must be observed, that strong stomachs, and stomachs especially habituated to digest any particular species of food, so as to convert it into the three essential parts of the chyle, derive perfect nourishment from such food whatever it be. A Laplander thus lives upon reindeer alone, without intermixing for most part of the year any vegetable food. No putrescent matter is formed in his stomach or organs of digestion, none enters his blood vessels along with the chyle.

An inhabitant of the banks of Orange river, in Africa, lives upon limpets, dead and putrid seals and whales, without tasting a particle of vegetable food of any kind whatever, excepting aromatics. The inhabitants of this country three centuries ago lived for at least six months of the year principally upon salted
animal

animal food, without any other vegetable substance than farinaceous matter, yet no sea scurvy arose in them, or any other detriment.

It is not then that food of any one, or any other kind, is more or less capable in itself of affording chyle perfectly good and intermixed with no noxious matter, but different species of food must be so adapted to the particular state the stomach and organs of digestion are now in, in order to be that which is most proper, or what is commonly called wholesome; or in other words, no food is in itself wholesome or unwholesome, but as it is compared with the present state of the stomach and other organs of digestion.

The next circumstance that offers itself to our observation, is the effect of the coagulating juice of the stomach on the food.

Milk is that food which comes nearest to the chyle in its external appearances, therefore,

fore, and as it is also a food which is formed for the nourishment of young animals, while their organs of digestion are weak, and their growth is at the same time very quick, it may be conjectured that they require greater nourishment; thus it offers itself as an obvious proposition, that chyle is ready prepared, or nearly so, in the vessels of the mother, in order to save the powers of digestion in the infant. But we have seen that there is a juice contained and constantly formed in the stomach, which coagulates this food in a few minutes after it is thrown in, retards it in the stomach, and retains it there for a considerable length of time. This of itself would sufficiently prove, that there is a process which must be gone through in the stomach itself necessarily for the formation of the chyle. This is farther confirmed by this coagulating juice producing the same effect of coagulating in like manner the white of an egg, which by its properties cannot be distinguished from the essential part of the serum of blood into which it is partly to be converted. This
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coagulating juice has an equal effect upon the serum of blood itself, even of the very same animal. Now it never could happen that the stomach could have a juice endowed with this property, if it were not necessary to arrest the food in the stomach for a certain length of time, in order that it should undergo a change in the stomach itself. It farther appears from experiment, that food dissolved in water, so as to form a solution not capable of being coagulated, and not detained by intermixture with solid matter, gives very little nourishment in proportion to the same quantity of the same food given in a solid form, or a coagulable one. Thus for example, if a solid piece of flesh be dissolved in water by simple boiling, or by Papin's digestion, and exhibited to an animal, it is not capable of being coagulated by the coagulating juice of the stomach, and does not give nearly that quantity of nourishment which it gives if employed in a solid form, without being previously dissolved in water. So in like manner the white of an egg exhibited in a fluid state,

state, as it is found in the egg, gives great nourishment, as I know from experiment, being coagulable and becoming solid in the stomach. But if the same white of egg be coagulated by heat, and boiled or digested in a Papin's digester, and so dissolved in water and exhibited, it does not now coagulate from the application of the coagulating juice of the stomach, and does not yield nearly the same quantity of nourishment. It requires, therefore, that the food should be arrested for a certain time in the digesting stomach of animals, in order there to undergo a certain change. Nor is this only necessary in the stomachs of men, quadrupeds, and other animals which have compleat sets of organs of digestion, but likewise in a leach, polypus, and other animals which have only one cavity, from whence apparently the food is absorbed after the manner in which the vessels of plants take their food from the earth; in these animals food remains for a considerable time in the stomach, and undergoes a change before it enters into their other vessels.

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In some animals the food is detained, as I have already shown, in cavities, before it comes into the digesting stomach. In Mr. Hunter's paper on Digestion, published by the Royal Society, there is this observation, which affords very strong ground to found a knowledge of the cause and uses of these previous stomachs; milk sucked by a calf does not remain in any of the previous stomachs, but passes down instantly into the digesting stomach, not requiring any previous operation, but grass remains for a length of time in the previous stomachs. It is therefore the nature, that is to say, the qualities of the food which renders it necessary that it should remain in these previous stomachs.

Let us consider what these qualities are, by observing what food is actually accumulated and detained in the previous stomachs.

First then, those animals which live entirely or mostly upon the fibrous parts of vegetables

vegetables have previous stomachs. These fibres are, as I have already observed, evidently not digestible in the human body, nor in the bodies of such animals as have not previous stomachs, excepting in some animals, which by men, and for the use of mankind, had been brought out of their natural habits of life, and altered entirely in their mode of living, and from which, therefore, we can draw no conclusion. All quadrupeds, which we know distinctly in their natural state to live only or principally upon the fibrous parts of vegetables, have previous stomachs. We may suppose, therefore, that some alteration should necessarily happen to the fibrous parts of vegetables before they enter into the digesting stomachs of quadrupeds.

One might readily suppose that the saccharine, vinous, and acetous fermentations might take place in these vegetable fibres, or some part of them at least. That the acetous fermentation does not take place in these previous stomachs is quite evident,

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because not only no proportion of alkali, however small, can be saturated by food just as it is entering into the digesting stomach, nor can the colour of any vegetable juice which is acted upon by acids, show the smallest degree of acidity. There not being, when the animal is in perfect health, the smallest quantity of vapour to be found in these previous stomachs, it cannot be imagined that the vinous fermentation takes place; not but that in quadrupeds of the ruminating class, such as the cow, when these previous stomachs are not sufficiently powerful to prevent the natural fermentations which would take place in similar chemical circumstances, only not in a living and powerful stomach, vapour is actually extricated in such quantity as to produce tumor, which is fatal, as I have seen myself in several instances; but when these previous stomachs are powerful enough to prevent the ordinary fermentations as above, there is no vapour found, nor any acid. The saccharine fermentation is not marked with such obvious circumstances as to determine,

termine, without an investigation by experiment, which I have not been as yet able to contrive or enter into. The only analogy is, that grass thrown together with a small degree of moisture ferments, as is shown by the heat it acquires, and contains a larger quantity of sugar, as has been proved; not only by the greater sweetness of taste, but from actual extraction, and gives more nourishment than if it had been simply dried, without being converted into hay, as is known to every farmer. Yet I cannot allow myself to believe, that even this fermentation takes place in the previous stomachs of quadrupeds which live on, and are nourished by, the fibrous parts of vegetables. I should rather think with Mr. Hunter, that in the previous stomachs of quadrupeds living upon the fibrous parts of vegetables in a great degree, that it was softening only, and fresh trituration in ruminating animals, that rendered their food more apt or capable of entering into the processes which take place in the digesting stomach.

Yet, nevertheless, it may be, that some process may take place in the previous stomachs of animals using this food which may decompose the matter, and reunite its particles into a new compound, which may be fitted to undergo a fresh change in the digesting stomach.

As to other species of food which are accumulated in one cavity, such as the craw of a bird, that accumulation seems merely, because the gizzard, in which it is to be ground into small particles for the digesting stomach, is not large enough, and is improper to grind that quantity at once, which is to be passed from the gizzard in order for its digestion. In the craw and gizzard they seem not to be altered at all, excepting in so far as they are soaked in watery fluids, the craw and gizzard as living parts of the body, having no power over them, farther than preventing them from entering into the saccharine, vinous, and acetous fermentations, as they would do, as has been already insisted upon. Possibly
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then a change of combination, and consequently of properties, may happen in the previous stomachs of ruminating animals, converting the fibrous parts of vegetables into another substance, which may be capable of undergoing a fresh change in the digesting stomach, and it may also be possible that the bulging part of the digesting stomach may in some cases produce this change, if such an one actually takes place,

In the human stomach, where the different species of food which I have enumerated, are capable of being converted into chyle, it can hardly be doubted that a decomposition and recombination takes place, but this decomposition and recombination does not appear to be the formation of chyle.

First, I conclude, that there is a decomposition and recombination of the elements of the food; because, as has been before observed, milk, serum of blood, and other substances most similar to the chyle and blood to be produced, are coagulated and

arrested in the stomach, in order to undergo a change, and do not go out of the stomach, until the firmness and texture of that coagulum is entirely dissolved and destroyed. Secondly, solid food, as has also been observed, when given in a solid form, or in such a state as is capable of being rendered solid in the stomach by coagulation, yields a much larger quantity of nourishment than it does, if it be dissolved in water, so as to pass soon out of the stomach, and not remain until it undergoes the action of its powers. In the next place, although it is the nature of that operation by which one compound is converted into another by the particles of the different species of matter, of which it consists, separating from one another, and recombining in a new manner, so as to form a fresh compound, without admitting fresh matter into it, to be instantaneous : so that the smallest integrant part of one compound in an infinitely small quantity of time is converted into a smallest integrant part of a new compound ; and as soon as the operation begins, it may be concluded in an extreme

extreme small quantity of time ; and all the smallest integrant parts of one compound may be converted into all the integrant parts of the other compound ; so that in one instant we may have the whole materials as much changed, as if that which was this moment a cup of glass may in the next be a cup of gold : this does not happen commonly ; for when such changes take place, a few of the smallest integrant parts of the one body are converted into a few of the smallest integrant parts of the other body, and as soon as the operation commences, there is an admixture of the first and second compound. Thus, for instance, when farinaceous matter is converted into sugar by this kind of operation, the whole mass is compleatly farinaceous matter before the operation commences ; but after the first instant of the operation there is a quantity of sugar formed, and as much less farinaceous matter left ; that is, supposing there were at the beginning one hundred of the smallest possible parts of farinaceous matter, after the first moment of the opera-

tion there perhaps might be 99 particles of farinaceous matter left, and one particle of sugar formed; which sugar would be as perfect sugar as that which is produced at the end of the operation. Therefore the conversion does not take place by such succession, that first, one property is given to the matter to be changed, then another, and so on until it becomes perfect. It is not as when we sow the seed of a plant, that a new plant to be produced acquires first a radicle, then a plumule, then a stem, leaves, flowers and fruit, but it is as if the whole plant was generated at once in all its parts, and all its perfection. As this is to be considered as the state of the operation, supposing farinaceous matter to be the food to be digested, a particle or particles would be completely and instantly changed into another substance, viz. the matter formed in the stomach, which matter cannot be chyle; for if it was into chyle, then the absorbents which are numerous in the stomach would take it up as fast

fast as it is produced, and would have the appearance of, and actually be lacteals, and be perceived : now, if we open a living animal at any time of the digestion, there is no appearance of any chyle absorbed from the stomach, and therefore we may, and must conclude, that there is none there to be absorbed.

If we throw milk into a portion of the jejunum, that milk will be absorbed by the lacteals ; but if we throw milk into the stomach of the same animal, the milk will not be absorbed by the lymphatics ; therefore an argument might be brought that the absorbents of the stomach would refuse what the absorbents of the jejunum would readily take up. But it must be considered that the milk is instantly coagulated in the stomach, and not in the jejunum, which coagulation will perfectly prevent it from being absorbed ; but all those substances which are not changed by the coagulating juice of the stomach will be, and are equally
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taken up by the lymphatics in the stomach and lacteals. Therefore there is a conversion of the food in the stomach into a new substance, whose properties are at present unknown, which new substance is the only one which can be converted into chyle in the duodenum and jejunum, exactly as we may form farinaceous matter, mucilage, and native vegetable acid into wine; but before they can possibly be converted into wine, they must first be formed into sugar. So in like manner farinaceous matter, gum, and white of egg, are all capable of forming chyle; but before they are formed into chyle, they must be converted into a matter certainly not sugar, but a matter of a particular species in the stomach, and by the operation of the stomach, this particular species of matter is afterwards converted into chyle in the duodenum and jejunum.

This operation, which forms part of the whole digestion, and which is performed in and is proper to the stomach, is one of those

those operations which depend on the action of the living solids upon the fluids, which appears clearly from various circumstances which I have already set forth. First, the interior surface of the digesting stomach is quite different, as I have already shown, from the surfaces both of the œsophagus, previous cavities, duodenum, and jejunum, being formed as it were of cells, including smaller cells in gradation, so as to give an immense living surface to act upon the food, and so give it the circumstances of the operation peculiar to the stomach, and overcome the natural disposition of the food to run into fermentations, that would out of the stomach convert it into wine and vinegar, or into putrid matter. Moreover, if we take a solid piece of meat, put it into a bag similar to the stomach, moisten it with water, keep it in the same degree of heat, and other chemical circumstances, such as we find in the stomach, it will remain strong and firm in its consistence for more than twenty-four hours ; whereas in the stomach when sufficiently powerful it is broken down,

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and its texture so entirely destroyed as to be perfectly diffusible, or at least miscible with water, in less than six hours; but if the stomach be weak, it will remain there for days, as I have already said; therefore the operation of the stomach is such as to occasion solids to be broken down much more readily than they otherwise would be, not by the force of grinding, but by a change of the food into the matter produced in the stomach. In the next place, the muscular fibres of the stomach are such, and in such directions as to roll the substances round and round, and bring them near, and apply them to the living parts, so as to keep the whole perfectly intermixed, and successively acted upon by the living surface of the stomach, so as to keep up the operation in the whole mass equally.

When a living solid acts upon a fluid, so as to affect its properties, it seems to act at a certain distance, and therefore, although matter not actually in contact with the surface of the stomach may be digested,
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yet it does not follow that the digestive process, or that part of it which takes place in the stomach, does not arise from the influence of the stomach. For if any species of food should be shut up in a glass, stone, or other vessel having holes in it, and be thrown into the stomach, the constant motion of the stomach would throw in through these holes matters already digested, which would pass out again, and give room for fresh matters to be applied, which would influence the contents of such vessel, so as to bring them into the same processes. Thus if we throw wine into a cask, whose surface is impregnated with vinegar, and into the middle of that wine we should throw a small cask with holes in it filled with a farinaceous paste, the sides of the cask impregnated with vinegar would not only give the wine a disposition to be converted into vinegar, but would also occasion the farinaceous paste enclosed in a smaller cask to be converted into vinegar likewise.

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The action of the living surface of the stomach has a greater effect on the substances contained, because the motion of the stomach is slow, while the degree of contraction and consequent pressure is moderate, as by this means the food will be successively applied to the surface, and remain upon it for a length of time sufficient to be affected by it; whereas by a more violent pressure, food will be squeezed out through the pylorus before it was digested, and in a more violent motion it would not have been left to have a sufficient impression, and therefore would not have undergone the proper process of the stomach.

The process of the stomach is the most essential in the digestion by much. For if every species of food, whatever it might be, consists, as I have already shown, of the same elements; and if, as I have likewise shown, the additions made in the organs of digestion are only to direct the decomposition and recombination of the elements of the food, so as to form it into the substance produced

produced by the process of the stomach, or afford water to it, then the whole action, which is material in regard to the food, is only connected with the stomach in its peculiar process. If this be the case, whatever the food may be, whether it be easily forced into the process of the stomach, or with difficulty, yet when actually forced into such process, and when it has gone through it, and been converted into the peculiar matter formed in the stomach it becomes the same. If such matter propelled into the duodenum, where it is to be formed into chyle, be always the same, the duodenum will have the power of converting it into the same chyle; and if the food does not go through the process of the stomach, it cannot be converted into chyle at all, as I have already shown. There is nothing, therefore, in the whole doctrine of different species of food which can have any respect to any part of the body, excepting the stomach itself. For food, considering any species of it as consisting of a vast number of homogeneous particles, may have every one of these particles converted
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into the matter produced by the process of the stomach ; and that being one species of matter only, will pass into the duodenum the same uniform substance, whatever the food may have been. Or supposing that none of these homogeneous particles are at all changed in the stomach, but pass into the duodenum as they were when they were swallowed, in that case none of them can enter into the process of the duodenum, and be converted into chyle, but must pass on and be evacuated. Or suppose one half, or any other proportion of the homogeneous particles of one species of food to undergo the operation of the stomach ; and the other half, or whatever proportion it may be, to remain unaltered and pass into the duodenum ; then that part which underwent the process of the stomach when it got into the duodenum would be converted by the process of the duodenum into chyle, and that part which did not go through the process of the stomach, would not be capable of going through the process of the duodenum, but must pass forward and be
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evacuated. The first, therefore, and great ground on which we are to consider food, is its disposition to be acted upon by the powers of the stomach, in the state the stomach is in; for whatever species of food is thrown into the stomach, if it yields to the action of the stomach, so as to be converted into the matter formed by the process of the stomach, it will certainly, the whole of it, be formed into the same chyle, and the same blood. So that it is perfectly immaterial what it may be, farinaceous matter, animal mucilage, apples, potatoes, wheat, mushrooms, or oysters, beef, veal, chicken, salmon, or goose. So long as it has undergone the process of the stomach, and been converted into the matter formed by that process, it gives equally good nourishment, and is equally innoxious, because it becomes exactly the same.

In so far, therefore, the whole enquiry with regard to the food will be confined to the consideration in the first place of what substances can ever be converted into the

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matter formed in the stomach, and which of these substances are adapted to the stomach in its present state, so as that it shall be readily brought into the process of the stomach, and be converted into the peculiar matter formed by that process.

However, there is another consideration which I have also shown the grounds of, that the food may be converted into acid, or putrid, or perhaps other noxious matter, which may hurt the duodenum and lower intestines as it passes on. It will be therefore also a consideration, whether in describing proper food according to the present state of the stomach, that part which is not changed into the matter produced by the process of the stomach passes on simply, and undergoes no change, or whether it enters into some fermentation in the stomach, which may render it noxious to the stomach itself, or to the duodenum, and other intestines which it may pass through.

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In considering proper food, whatever particular state the stomach may be in, no man would ever advise a food, which although it might be digested readily, might at the same time, by its own qualities, be noxious. For example, although the poison of a rattle-snake may be digested and formed into chyle; yet if there should be the least bit of sore or wound in the stomach, it must prove immediately fatal. Much less would any one advise the use of any food found naturally mixed with a noxious substance, unless that noxious matter was first separated. Thus many species of arum contain farinaceous matter, or gum, which are nourishing; but mixed naturally with so acrid a juice as would often prove poisonous, excepting when the acrid matter is gone off by keeping it some time after it is gathered, then the farinaceous matter and gum are the same as when found in any other vegetable. But we are not at present to enter generally into practical details with regard to the food.

We are to consider its farther progress after it has passed out of the stomach.

I have already contended, that chyle is not formed in the stomach. Sometimes a little whitish matter is seen about the pylorus; but if it were perfect chyle it would be absorbed, and shown, as I have already said, in the absorbents of the stomach, which it is not, even if in the middle of the digestion the pylorus is tied round by introducing a piece of tape, and forming a ligature round it, and retaining the remaining food in the stomach. The matter formed in the stomach is therefore converted in the duodenum, and continues to be converted in the jejunum into chyle.

As the coagulating juice of the stomach, as far as we can judge, does not all, or any part of it, enter into the matter formed from the food in the stomach, and the other juices of the stomach, only in so far as they apply water, these juices of the stomach only assist in regulating the process of the

the stomach and the food, so neither do the juices of the duodenum, either the bile, pancreatic juice, fluids secreted in the glands of the duodenum, or which may pass through the exhalents, at all appear to enter into any part of the chyle. For if in the body when it is whole a stone should obstruct the ductus communis choledochus, so as to prevent bile altogether from getting into the duodenum; or if we open the body of an animal, when food has been thrown into the stomach, and tie up the ductus choledochus, so as to prevent any bile from getting into the duodenum; in either case chyle is formed without any particle of bile being admixed; and the same may be said of the pancreatic juice; so that chyle is solely the product of the matter formed by the digestive process of the stomach.

Chyle in itself is always the same, but not always in the same quantity in proportion to the food. For in the stomach itself, when a great quantity of food is thrown

in, part of it may be digested and converted into the substance formed by the process of the stomach, and part of it may be sent into the duodenum to pass off unaltered; which, however, is often dubious, because on examining the food in the duodenum, we hardly ever find any digestible matter in the form it was thrown into the stomach. If the whole of the food be converted into the matter formed by the process of the stomach, in the duodenum part may be converted into chyle, and part be passed forward without any farther change. Or that part which was not converted into chyle, may be converted into some other substance which may pass through the lacteals into the blood vessels, and be evacuated by the different excretories of the body. Or the whole being converted into chyle, part of that chyle may be formed into blood, and part of it may undergo some other process, which may render it capable of passing off through the different excretories, or deposit it in some of the cavities of the body out of the course of circulation. But all
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this goes far beyond the limits to which I am restricted, and therefore I shall endeavour to point out what objects I had in view to lay before you.

First, the structure of the organs of digestion. Secondly, the matters applied to the food in the organs of digestion. In the next place the substances employed for food. Then to point out that all the substances employed for food, had all and every one of them the same elements exactly, and each of them all the elements necessary for the formation of chyle; that is, all the elements that are actually found in chyle. That therefore it was only necessary that these elements should be separated from one another, and recombined, in order for its formation. That the action of the stomach, duodenum, and perhaps jejunum, together with the fluids applied, induced in the matter employed for food one operation, by which its elements were disunited, and reunited in a new manner, and into a new matter; which matter, although it might
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be mixed with other substances, was in itself always the same in all its properties, and that this matter was by a new operation induced by the action of the duodenum, and the fluids it met with there, to have its elements again disunited, and reunited so as to form the three essential parts of the chyle, which, therefore, could not be influenced in the smallest degree by the food, and that these three essential parts of the chyle were always the same, and therefore when converted into the blood, the blood a fortiori could not be in the smallest degree influenced by the food. And moreover, that provided a sufficient quantity of food was employed, and the organs of digestion were sufficiently powerful in their action, and the fluids applied were properly added, a sufficient quantity of blood would be formed, and that too large a quantity of food did not produce too large a quantity of blood.

F I N I S.

